

Oxford Cambridge and RSA Examinations

RECOGNISING ACHIEVEMENT

| ADVANCED GCE | A2 7888 |
|-------------------------|---------|
| ADVANCED SUBSIDIARY GCE | AS 3888 |

PHYSICS B (ADVANCING PHYSICS)

MARK SCHEME FOR THE UNITS JUNE 2004

AS/A2



3888/7888/MS/04

Advanced Subsidiary GCE Physics B (Advancing Physics) 3888 June 2004 Assessment Session

Unit Threshold Marks

| Unit | ····· | Maximum Mark | а | b | c | d | e | u |
|------|-------|-----------------|----|----|----|----|----|---|
| 2860 | Raw | 90 | 64 | 56 | 49 | 42 | 35 | 0 |
| | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 2861 | Raw | 90 | 59 | 51 | 44 | 37 | 30 | 0 |
| | UMS | 110 | 88 | 77 | 66 | 55 | 44 | 0 |
| 2862 | Raw | 120 | 97 | 85 | 73 | 62 | 51 | 0 |
| | UMS | 90 | 72 | 63 | 54 | 45 | 36 | 0 |

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

| | Maximum Mark | Α | В | С | D | E | U |
|------|-----------------|-----|-----|-----|-----|-----|---|
| 3888 | 300 | 240 | 210 | 180 | 150 | 120 | 0 |

The cumulative percentage of candidates awarded each grade was as follows:

| | Α | В | С | D | E | U | Total Number of Candidates |
|------|------|------|------|------|------|-------|-------------------------------|
| 3888 | 24.0 | 43.7 | 62.3 | 79.6 | 91.0 | 100.0 | 6682 |

Advanced GCE Physics B (Advancing Physics) 7888 June 2004 Assessment Session

Unit Threshold Marks

| Unit | | Maximum Mark | а | b | С | d | e | u |
|-------|-----|-----------------|----|----|----|----|----|---|
| 2863A | Raw | 127 | 96 | 86 | 76 | 66 | 56 | 0 |
| | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 2863B | Raw | 127 | 96 | 86 | 76 | 66 | 56 | 0 |
| | UMS | 100 | 80 | 70 | 60 | 50 | 40 | 0 |
| 2864A | Raw | 119 | 92 | 82 | 72 | 62 | 53 | 0 |
| | UMS | 110 | 88 | 77 | 66 | 55 | 44 | 0 |
| 2864B | Raw | 119 | 92 | 82 | 73 | 64 | 55 | 0 |
| | UMS | 110 | 88 | 77 | 66 | 55 | 44 | 0 |
| 2865 | Raw | 90 | 66 | 59 | 52 | 46 | 40 | 0 |
| | UMS | 90 | 72 | 63 | 54 | 45 | 36 | 0 |

Specification Aggregation Results

Overall threshold marks in UMS (i.e. after conversion of raw marks to uniform marks)

| | Maximum Mark | Α | В | С | D | E | U |
|------|-----------------|-----|-----|-----|-----|-----|---|
| 7888 | 600 | 480 | 420 | 360 | 300 | 240 | 0 |

The cumulative percentage of candidates awarded each grade was as follows:

| | A | В | С | D | E | U | Total Number of Candidates |
|------|------|------|------|------|------|-------|-------------------------------|
| 7888 | 30.7 | 52.9 | 73.0 | 88.2 | 96.9 | 100.0 | 5214 |

Physics B (Advancing Physics) mark schemes - an introduction

Just as the philosophy of the *Advancing Physics* course develops the student's understanding of Physics, so the philosophy of the examination rewards the candidate for showing that understanding. These mark schemes must be viewed in that light, for in practice the examiners' standardisation meeting is of at least equal importance.

The following points need to be borne in mind when reading the published mark schemes:

- Alternative approaches to a question are rewarded equally with that given in the scheme, provided that the physics is sound. As an example, when a candidate is required to "Show that..." followed by a numerical value, it is always possible to work back from the required value to the data.
- Open questions, such as the questions in section C permit a very wide variety of approaches, and the candidate's own approach must be rewarded according to the degree to which it has been successful. Real examples of differing approaches are discussed in standardisation meetings, and specimen answers produced by candidates are used as 'case law' for examiners when marking scripts.
- Final and intermediate calculated values in the schemes are given to assist the examiners in spotting whether candidates are proceeding correctly. Mark schemes frequently give calculated values to degrees of precision greater than those warranted by the data, to show values that one might expect to see in candidates' working.
- Where a calculation is worth two marks, one mark is generally given for the method, and the other for the evaluation of the quantity to be calculated.
- If part of a question uses a value calculated earlier, any error in the former result is not penalised further, being counted as *error carried forward*: the candidate's own previous result is taken as correct for the subsequent calculation.
- Inappropriate numbers of significant figures in a final answer are penalised by the loss of a
 mark, generally once per examination paper. The maximum number of significant figures
 deemed to be permissible is one more than that given in the data; two more significant figures
 would be excessive. This does not apply in questions where candidates are required to show
 that a given value is correct.
- Where units are not provided in the question or answer line the candidate is expected to give the units used in the answer.
- Quality of written communication will be assessed where there are opportunities to write extended prose.

SECTION C

The outline mark schemes given here will be given more clarity by the papers seen when the examination is taken. Some of these scripts will be used as case law to establish the quality of answer required to gain the marks available.

It is not possible to write a mark scheme that anticipates every example which students have studied.

For some of the longer descriptive questions three marks will be used (in scheme called the 1/2/3 style).

- 1 will indicate an attempt has been made
- 2 will indicate the description is satisfactory, but contains errors
- 3 will indicate the description is essentially correct

| Qn | Expected Answers | Marks | Additional guidance |
|---------------------|---|--------------------------|---|
| 1 | Section A tough ✓ | 1 | |
| 2a; b; c | i) B ii) A ✓ ; a light line / low values AW ✓ ; smoothing / averaging / mean / median AW ✓ | 1 1 1 | both for the mark at 10 / near zero NOT just filter |
| 3a b | <i>r</i> correctly labelled \checkmark ; rearrangement or substitution sin <i>r</i> = sin 80°/1.3 \checkmark ; correct value for <i>r</i> = 49.(2)° \checkmark ; accept 1/2/3 S.F. \checkmark | 1 1 2 | sin 80° / sin $r = 1.3$ S.F. mark not penalty accept 50° |
| 4a b | = 220 / 880 / = ¼ / 1 : 4 ✓ ; method = 220 x 6 / (220+880) / correct symbolic✓ ; evaluation = 1.2 V ✓ | 1 1 1 | accept 0.25 NOT 4 accept 6 / 5 |
| 5a b | $P = IV = IIR = (I^2R) / P/I = I R \text{ and } P = I^2R \checkmark;$ 4 | 1 | NO ecf from (a) |
| 6 | e.g. rotate T / R / grille / slit (about x-axis) ✓ ; loudness varies ✓ ; reaches zero / minimum after 90° rotation ora ✓ | 1 1 1 | accept any other valid method e.g.rotating a metal grille 1/2/3 style AW |
| 7ai; ii bi;ii | 50 μs ✓ ; 20 000 Hz ✓ ; 3 bits ✓ ; 3 x 10 ⁶ bits s ⁻¹ ✓ Total section A | 1 1 <u>2</u> 20 | accept up to 52µs ecf on 1/T ecf on bits x 10 ⁶ |

| Section B8a: Angle of incident ray correct by eye \checkmark ; adv. wider angle of view \checkmark ; disadv. missing angles / non-continuous field of view / hazard \checkmark ;1iii construction (G = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (G = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (G = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (G = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (G = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (G = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (C = 1/V) = 50/12 \checkmark ; = 4.17 / 4.2 Å \checkmark ; (C = 1/V) = 50/12 \checkmark ; = 0.347 S \checkmark ; (C = 1/T) \land NOT see more other sensible accept and in a lia allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii allow ecf on 4.0 Å i.e. 0.33 S rearrange: decimal evaluation i and ii accept same image accept 1.22 M(bits)9a50 \pm 20 pixels \checkmark ; i. 1 accept same image i.e. 0.347 x 0.2 / (3.1 x 10 5 \checkmark ; (= 8 x 10 7) ora ii iii; use of geometry similar triangles / equal angles \checkmark ; i. 1 i.e. 0.2 / 2 V / consistent with the y-intercept of their graph 2. r = gradient / (E - V) / I / = V_{LOST} / I \checkmark ; e.g. = (0.0 - 0)/2.0 \checkmark ; = 3.0 $\%$ or working max 1 do iii iii iii e.g. = (0.0 - 0)/2.0 \checkmark ; = 3.0 $\%$ or working max 1 do eriset at with their graph i 2. r = gradient / (E - V) / I / = V_{LOST} / I \checkmark ; e.g. = (0.0 - 0)/2.0 \checkmark ; = 3.0 | Qn | Expected Answers | Marks | Additional guidance |
|--|------|---|-----------|-----------------------------|
| Ba: b: adv. wider angle of incident ray correct by eye \checkmark ; incon-continuous field of view /, disack-missing angles / non-continuous field of view / hazard \checkmark ; is uggestions it is $(G = I/V) = 4.17/12 \checkmark$; $= 0.347 S \checkmark$; ii ii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x 0.08) OR = 2.2 \times 10^{-7} m^2 \checkmark$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x - 0.5) \land$; iii $I = 0.347 \times 0.2/(3.1 \times 10^{-5} x - 0.5) \land$; iii $I = 0.348 \times 10^{-7} = 1.22 \times 10^{-7} m \checkmark$ must match their (a) accept same image accept same ima | | Section B | | |
| b; adv. wider angle of view $<$; disadv. missing angles / non-continuous field of view / hazard $<$; and the sensible suggestions rearrange; decimal ($G = 1/V$) = 50/12 $<$; = 4.17 / 4.2 A $<$; and the sensible suggestions rearrange; decimal ($G = 1/V$) = 4.17/12 $<$; = 0.347 S $<$; and the sensible suggestions rearrange; decimal evaluation i and ii allow eff on 4.0 A is test to $= 0.347 \times 0.2/(3.1 \times 10^{-5} \times 0.08) \text{ OR } = 2.2 \times 10^{7} \text{ m}^{2} <$; and the substitution i and ii allow eff on 4.0 A is test to $= 0.347 \times 0.2/(3.1 \times 10^{-5} \times 0.08) \text{ OR } = 2.2 \times 10^{7} \text{ m}^{2} <$; arrange; decimal evaluation i and ii allow eff on 4.0 A is test to $= 0.347 \times 0.2/(3.1 \times 10^{-5} \times 0.08) \text{ OR } = 2.2 \times 10^{7} \text{ m}^{2} <$; arrange; arrang | 8a; | Angle of incident ray correct by eye ✓ ; | 1 | |
| non-continuous field of view / hazard \checkmark : in controm the product of the sensible suggestions is and if it is if | b; | adv. wider angle of view ✓; disadv. missing angles / | 1 | NOT see more |
| ci $I = P/V$ $I = 50/12 \checkmark$; $= 4.17 I 4.2 A \checkmark$; $G = I/V$ $I = 50/12 \checkmark$; $= 4.17 I 4.2 A \checkmark$; $G = I/V$ $I = 50/12 \checkmark$; $= 4.17 I 4.2 A \checkmark$; $G = I/V$ $I = 50/12 \checkmark$; $= 0.347 S \checkmark$; $I = C = C I \land \sigma$ $A = G L / \sigma \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 2.8 \times 10^{-6} m \checkmark$ $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 2.8 \times 10^{-6} m \checkmark$ $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 2.8 \times 10^{-6} m \checkmark$ $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.347 \times 0.2 I (3.1 \times 10^{5} \times 0.08) OR = 2.2 \times 10^{7} m^{2} \checkmark$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.37 \times 10^{7} m^{2} \times 10^{7} \Lambda$; $I = 0.30 \times 10^{7} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 10^{9} m^{7} \times 10^{7} \Lambda$; $I = 0.005 \times 5.00 \times 1$ | | non-continuous field of view / hazard √; | 1 | other sensible |
| ci $J = P/V$ / $I = 50/12 \lor ; = 4.17/14.2 A \lor ;$ ($G = I/V$) = 4.17/12 \lor ; = 0.347 S \lor ; ii $I = 0.47 \land 0.2 / (3.1 \times 10^5 \times 0.08) OR = 2.2 \times 10^7 m^2 \lor ;$ ii $I = 0.347 \times 0.2 / (3.1 \times 10^5 \times 0.08) OR = 2.2 \times 10^7 m^2 \lor ;$ = 2.8 × 10 6 m ∨ = 10 9a 50 ± 20 pixels ∨; = 1.28 M(bits) ∨ | | | - | suggestions |
| $ \begin{array}{cccc} (C = 1/V) &= 4.1/1/12^{-V} &:= 0.347 \times 5^{-V} &:\\ \hline \\ \hline$ | ci | $I = P/V$ / = 50/12 \checkmark ; = 4.17 / 4.2 A \checkmark ; | 2 | rearrange ; decimal |
| iii $I = 6L / \sigma h$ OR $A = 6L / \sigma <$; iii $I = 0.347 \times 0.2 / (3.1 \times 10^{5} \times 0.08)$ OR $= 2.2 \times 10^{7}$ m ² /; $= 2.8 \times 10^{-6}$ m $<$ 9a 50 ± 20 pixels $<$; b $135 / (a) = 2 \sigma 3 \text{ or } 4 \text{ or } 5 (\text{ to } 1 \text{ S.F.}) <$; c same length per pixel AW $<$; 1 $135 / (a) = 2 \sigma 3 \text{ or } 4 \text{ or } 5 (\text{ to } 1 \text{ S.F.}) <$; 1 must match their (a) accept same image accept 1.22 M(bits) $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3}$ m $<$; 1 $10^{-2} / 1 / 2 \times 10^{-5} / 1 / <$; 1 $10^{-2} / 1 / 2 \times 10^{-5} / 1 / <$; 1 $10^{-2} / 1 / 2 \times 10^{-5} / 1 / <$; 1 $10^{-2} / 1 / 2 \times 10^{-5} / 1 / <$; 1 $10^{-2} / 1 / 2 \times 10^{-5} / 1 / <$; 1 $10^{-2} / 1 / 2 \times 10^{-5} / 1 / 2 \times 10^{-5} / 1 / <$; 2 $11^{-2} / 1 / 2 \times 10^{-5} / 1 / 2 \times 10^{-5} / 1 / <$; 2 $11^{-2} / 1 / 2 \times 10^{-5} / 1 / 1 / 2 \times 10^{-5} / $ | | $(G = I/V) = 4.17/12 \checkmark ; = 0.347 S \checkmark ;$ | • | |
| iii $F = G L / \sigma h$ OR $A = G L / \sigma \sqrt{2}$; i1Its. 0.35 d rearrangementiii $= 0.347 \times 0.2 / (3.1 \times 10^{5} \times 0.08) \text{ OR} = 2.2 \times 10^{7} \text{ m}^{2} <;$ 1rearrangement $= 0.347 \times 0.2 / (3.1 \times 10^{5} \times 0.08) \text{ OR} = 2.2 \times 10^{7} \text{ m}^{2} <;$ 1rearrangement $= 0.347 \times 0.2 / (3.1 \times 10^{5} \times 0.08) \text{ OR} = 2.2 \times 10^{7} \text{ m}^{2} <;$ 1rearrangement $= 0.347 \times 0.2 / (3.1 \times 10^{5} \text{ m}^{2} <;$ 1substitution / evaluationfill $= 2 \text{ or 3 or 4 or 5 (to 1 S.F.) < ;}$ 1must match their (a)accept 1.22 M(bits) <: | 11 | | | |
| iii $= 0.347 \times 0.27(3.1 \times 10^{-5} \times 0.08) OR = 2.2 \times 10^{-5} m^{-7};$ $= 2.8 \times 10^{-6} m^{-7}$ iii $= 2.8 \times 10^{-7} m^{-7}$ iv $= 2.8 \times 10^{-7} m^{-7} m^{-7}$ iv $= 2.8 \times 10^{$ | | $t = GL/\sigma h$ OR $A = GL/\sigma \checkmark$; | 1 | I.e. 0.33 S |
| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $ | 107 | $= 0.347 \times 0.27 (3.1 \times 10^{\circ} \times 0.08) \text{ OR} = 2.2 \times 10^{\circ} \text{ m}^{-1} \text{ ;}$ | 1 | substitution / evaluation |
| 9a50 ± 20 pixels \checkmark ;109a50 ± 20 pixels \checkmark ;10b135 / (a) = 2 or 3 or 4 or 5 (to 1 S.F.) \checkmark ;1csame length per pixel AW \checkmark ;1d128 M(bits) \checkmark ;1ei(M = v/u) = 0.16 / 2 x 10 ⁵ \checkmark ; (= 8 x 10 ⁻⁷) ora1ii10 3 / 8 x 10 $^{-7}$ = 1.25 x 10 ³ m \checkmark ;1iiiuse of geometry similar triangles / equal angles \checkmark ;1 <i>I</i> 10^3 / 8 x 10 $^{-7}$ = 1.25 x 10 ³ m \checkmark ;1iiiuse of geometry similar triangles / equal angles \checkmark ;1 <i>I</i> 10^3 / 8 x 10 $^{-7}$ = 1.25 x 10 ³ m \checkmark ;1iii:use of geometry similar triangles / equal angles \checkmark ;1 <i>I</i> $10ai$ any straight line of best fit judged by eve1ii1.6.0 ± 0.2 V / consistent with the y-intercept of their1graph2. r = gradient / (E · V) / I / = V _{LOST} / I \checkmark ;1e.g. = (6.0 - 0) / 2.0 \checkmark ; = 3.0 Ω \checkmark no working max 1any correct method;b(total) delivered internally and externally / of battery \checkmark 1ciR = V/I = 3(.0) Ω \checkmark and P = I V = 3(.0). W \checkmark ;1ci(efficiency = I V/I \mathcal{E} = 3.0 / 6.0) = 0.5 / 50% \checkmark ;1iii(efficiency = I 0.01 x 5.0 x 10 ³ any arrangement \checkmark ;1proportional up to point (250 MPa , 5%) \checkmark ;1correct substitutioniii $\sigma \in \mathcal{E}$ = 0.05 x 5.0 x 10 ³ any arrangement \checkmark ;1ci $A = \pi R^2 = \pi x (25 x 10^{-6})^2 = 1.96 x 10^{-9} m^2 \div;1iiiF = \sigma A / = 3.0 x $ | | = 2.8 × 10 ° m V | | final evaluation ecf |
| 9a 50 ± 20 pixels \checkmark ;109a 50 ± 20 pixels \checkmark ;1must match their (a)b $135 / (a) = 2 \text{ or } 3 \text{ or } 4 \text{ or } 5 (\text{ to } 1 \text{ S.F.}) \checkmark$;1must match their (a)csame length per pixel AW \checkmark ;1accept same imaged $1.28 \text{ M}(\text{bits}) \checkmark$;1accept $3.28 \text{ M}(\text{bits})$ iii $10^{-3} / 8 \times 10^{-7} = 1.25 \times 10^{3} \text{ m} \checkmark$;1iii;use of geometry similar triangles / equal angles \checkmark ;1iiii;use of geometry similar triangles / equal angles \checkmark ;1iiii; $0.6 \downarrow 0.2 \text{ V}$ / consistent with the y-intercept of their1graph2. r = gradient / $(E - V) / I / = V_{LOST} / I \checkmark$;1e.g. = (6.0 - 0) / 2.0 \checkmark ; $3.0 \Omega \checkmark$ no working max 1any correct method ;b(total) delivered internally and externally / of battery \checkmark 1ci $R = V / I = 3(0, \Omega \Delta' \text{ and } P = I V = 3(.0). W \checkmark$;2ci $R = V / I = 3(0, \Omega \Delta' \text{ and } P = I V = 3(.0). W \checkmark$;1ci(efficiency = $I V / I \mathcal{E} = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$;1iii $\sigma \in \mathcal{E} = 0.05 \times 5.0 \times 10^{-9}$ any arrangement \checkmark ;1the arr $R^2 = \pi x (25 \times 10^{-9} V)^2 = 1.96 \times 10^{-9} (25\%) <;$ 1iii $R = \sigma A = 3.0 \times 10^{-9} x = 2.59 / 0.6 N \times;$ 1ci $R = R R^2 = \pi x (25 \times 10^{-9} V)^2 = 1.96 \times 10^{-9} (25\%) <;$ 1diany shape ending at point (300MPa , 25\%) \checkmark ;1ci $R = \pi R^2 = \pi x (25 \times 10^{-9} V)^2 = 1.96 \times 10^{-9} (25\%) <0 N \times;$ 1any shape ending at point (| | | | |
| 9a 50 ± 20 pixels \checkmark ;1b $135/(a) = 2 \text{ or } 3 \text{ or } 4 \text{ or } 5 (\text{to } 1 \text{ S}, \text{F},)\checkmark$;1must match their (a)csame length per pixel AW \checkmark ;1accept same imaged $1.28 \text{ M(bits)} \checkmark$;1accept 1.22 M(bits)ei $(M = v/u) = 0.16 / 2 \times 10^5 \checkmark$; ($= 8 \times 10^7$) ora1iii $10^3 / 8 \times 10^{-7} = 1.25 \times 10^3 \text{ m } \checkmark$;1iii;use of geometry similar triangles / equal angles \checkmark ;1f $1/u \approx 0 \checkmark$;so $1/v \approx 1/t$ (and $v \approx f$) \checkmark 2OR correct numerical / curvature arguments910aiany straight line of best fit judged by eye1ii $1.6.0 \pm 0.2 \text{ V}$ / consistent with the y-intercept of their1graph $2.r$ = gradient / $(E - \text{V}) / 1$ / $= V_{LOST} / 1 \checkmark$;1any correct method;subtitution; evaluatione.g. = $(6.0 - 0) / 2.0 \checkmark$; $3.0 \Omega \checkmark$ no working max 1b(total) delivered internal; and externally / of battery \checkmark 1ii(efficiency = $1 \text{ V} / 1 \mathcal{E} = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$;1iii(efficiency = $1 \text{ V} / 1 \mathcal{E} = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$;1row shape ending at point (250 MPa, $5\%) \checkmark$;1correct substitution no line no marksiii $e \in \mathcal{E} = 0.05 \times 5.0 \times 10^3$ any arrangement \checkmark ;1correct substitution no line no marksiii $e \in \mathcal{E} = 1.25 \pm 0.1 \text{ W} / 1.9 \pm 1.0 \text{ W} \text{ W}$ 1correct substitution no line no marksiii $e \in \mathcal{E} = 0.25 \times 5.0 \times 10^3$ any arrangement \checkmark ;1correct substi | | | 10 | |
| b $135/(a) = 2 \text{ or } 3 \text{ or } 4 \text{ or } 5 (\text{ to } 1 \text{ S.F.}) \checkmark$; same length per pixel AW \checkmark ; ei $(M = v/u) = 0.16/2 \times 10^5 \checkmark$; $(=8 \times 10^7)$ ora ii $10^3/8 \times 10^{-7} = 1.25 \times 10^3 \text{ m} \checkmark$; ii; use of geometry similar triangles / equal angles \checkmark; f $1/u \approx 0 \checkmark$; so $1/v \approx 1/f$ (and $v \approx f) \checkmark$ OR correct numerical / curvature arguments ii $1.6.0 \pm 0.2 \text{ V}$ / consistent with the y-intercept of their graph 2. $r = \text{gradient} / (E - V) / I / = V_{\text{LOST}} / I \checkmark$; e.g. $= (6.0 - 0)/2.0 \checkmark$; $= 3.0 \Omega \checkmark$ no working max 1 ii (ottal) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; Power $= 2.5 \pm 0.1 \text{ W} / 1.6 \pm 0.1 \text{ W} / 1.9 \pm 0.1 \text{ W UP} \checkmark$ iii (officiency $= I V / I \mathcal{E} = 3.0/6.0) = 0.5 / 50\% \checkmark$; Power $= 2.5 \pm 0.1 \text{ W} / 1.6 \pm 0.1 \text{ W} / 1.9 \pm 0.1 \text{ W UP} \checkmark$ iii $\sigma = e \mathcal{E} = 0.05 \times 5.0 \times 10^9$ any arrangement \checkmark ; proportional up to point (250 MPa , 5\%) \checkmark; any shape ending at point (300MPa , 25\%) \checkmark ; iii $F = \sigma A / = 3.0 \times 10^6 \times 1.96 \times 10^9 \text{ m}^2 \checkmark$; iii $F = \sigma A / = 3.0 \times 10^6 \times 1.96 \times 10^9 \text{ m}^2 \checkmark$; iii $F = \sigma A / = 3.0 \times 10^6 \times 1.96 \times 10^9 \text{ m}^2 \checkmark$; iii any shape shifted to matrix and fibres; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends iii auggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark iii $\frac{1}{40}$ | 9a | 50 <u>+</u> 20 pixels ✓ ; | 1 | |
| c same length per pixel AW \checkmark ; d 1.28 M(bits) \checkmark ; ei (M = v/u) = 0.16 / 2 x 10 ⁵ \checkmark ; (= 8 x 10 ⁻⁷) ora ii 10 ⁻³ / 8 x 10 ⁻⁷ = 1.25 x 10 ³ m \checkmark ; use of geometry similar triangles / equal angles \checkmark ; f 1/u $\approx 0 \checkmark$; so 1/v $\approx 1/(f (and v \approx f) \checkmark$ OR correct numerical / curvature arguments ii 1.6.0 ± 0.2 V / consistent with the y-intercept of their graph 2. $r =$ gradient / ($\varepsilon - V$) / I / = V _{LOST} / I \checkmark ; e.g. = ($6.0 - 0$) / 2.0 \checkmark ; = 3.0 $\Omega \checkmark$ no working max 1 (total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; r = $V/I = 3(.0)\Omega \checkmark$ and $P = IV = 3(.0)_{-}W \checkmark$; ii (efficiency = $IV/I \mathcal{E}$ = $3.0/6.0$) = $0.5 / 50\% \checkmark$; iii (efficiency = $IV/I \mathcal{E}$ = $3.0/6.0$) = $0.5 / 50\% \checkmark$; iii $\sigma = \varepsilon \mathcal{E} = 0.05 x 5.0 x 10^{-9}$ any arrangement \checkmark ; proportional up to point (250 MPa, 5%) \checkmark ; iii $\sigma = \varepsilon \mathcal{E} = 0.05 x 5.0 x 10^{-9}$ any arrangement \checkmark ; proportional up to point (250 MPa, 5%) \checkmark ; iii $F = \sigma A / = 3.0 x 10^{-8} x 1.96 x 10^{-9} m^2 \checkmark;iii F = \sigma A / = 3.0 x 10^{-8} x 1.96 x 10^{-9} m^2 \checkmark;iii F = \sigma A / = 3.0 x 10^{-8} x 1.96 x 10^{-9} m^2 \checkmark;iii F = \sigma A / = 3.0 x 10^{-8} x 1.96 x 10^{-9} m^2 \checkmark;anisotropy : stronger axially than transverse - split endsiii again when stress is removed \checkmark;weak bonds between coiled molecules can uncoil and coil upagain when stress is removed \checkmark;weak bonds between coiled molecules can be brokenunder stress then reform when stress is removed /strong sulphur bonds to matrix pull coils back to shape \checkmark1.11.21.31.31.31.31.31.31.31.3$ | b | 135 / (a) = 2 or 3 or 4 or 5 (to 1 S.F.) ✓ ; | 1 | must match their (a) |
| d 1.28 M(bits) \checkmark ; ei (M = v/u) = 0.16 / 2 x 10 ⁵ \checkmark ; (= 8 x 10 ⁻⁷) ora ii 10 ⁻³ /8 x 10 ⁻⁷ = 1.25 x 10 ³ m \checkmark ; iii; use of geometry similar triangles / equal angles \checkmark ; f $1/u \approx 0 \checkmark$; so $1/v \approx 1/t$ (and $v \approx t$) \checkmark OR correct numerical / curvature arguments 10ai any straight line of best fit judged by eye ii 1.6.0 \pm 0.2 V / consistent with the y-intercept of their graph 2. $r =$ gradient / (E - V) / I / = V _{LOST} / I \checkmark ; e.g. = (6.0 - 0) / 2.0 \checkmark ; = 3.0 Ω \checkmark no working max 1 b (total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; ii (efficiency = IV/IE = $3.0/6.0$) = 0.5 / 50% \checkmark ; iii (efficiency = IV/IE = $3.0/6.0$) = 0.5 / 50% \checkmark ; iii (efficiency = IV/IE = $3.0/6.0$) = 0.5 / 50% \checkmark ; iii $Power = 2.5 \pm 0.1 W / 1.6 \pm 0.1 W / 1.9 \pm 0.1 W UP \checkmarkT consistent with graph consistent calculation of P from a graph point consistent calculation of P from a graph point (300MPa , 25%) \checkmark;any shape ending at point (300MPa , 25%) \checkmark;any mechanical property \checkmark of a composite related to microstructure \checkmark; explain by ref to matrix and fibres ;e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - spilt endssuggestics coiled protein molecules can uncoil and coil up again when stress is removed \checkmark;weak bonds between coiled molecules can be broken under stress then reform when stress is removed \checkmark;weak bonds between coiled molecules can be broken under stress then reform when stress is removed \checkmark;weak bonds between coiled molecules can be broken under stress then reform when stress is removed \checkmark strong sulphur bonds to matrix pull coils back to shape \checkmarkiii any support to matrix pull coils back to shape \checkmarkiii any stress then reform when stress is removed \checkmark;weak bonds between coiled molecules can be broken under stress then reform when stress is removed \checkmark;weak bonds between coiled molecules can be $ | с | same length per pixel AW ✓; | 1 | accept same image |
| ei $(M = v/u) = 0.16/2 \times 10^{\circ} \checkmark$; $(= 8 \times 10^{-7})$ ora 1 ii $10^{-3}/8 \times 10^{-7} = 1.25 \times 10^{3} m \checkmark$; 1 ii; use of geometry similar triangles / equal angles \checkmark ; 1 $1/u \approx 0 \checkmark$; so $1/v \approx 1/f$ (and $v \approx f$) \checkmark 2 OR correct numerical / curvature arguments 9 10ai any straight line of best fit judged by eye 1 ii $1.6.0 \pm 0.2 V$ / consistent with the y-intercept of their graph 2. $r =$ gradient / $(E - V) / I$ / $= V_{LOST} / I \checkmark$; 2 e.g. $= (6.0 - 0) / 2.0 \checkmark$; $= 3.0 \Omega \checkmark$ no working max 1 b (total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; 2 ci $R = V/I = 3(.0) \Omega \checkmark$ and $P = I V = 3(.0) W \checkmark$; 2 ii (efficiency = $I V / I E = 3.0 / 6.0$) $= 0.5 / 50\% \checkmark$; 1 iii (efficiency = $I V / I E = 3.0 / 6.0$) $= 0.5 / 50\% \checkmark$; 1 $1 correct substitution role culculation of P from a graph point consistent with graph consistent calculation of P from a graph point (300MPa, 25\%) \checkmark$; 1 iii $S = \varepsilon E = 0.05 \times 5.0 \times 10^{9}$ any arrangement \checkmark ; 1 $C = 3.0 \times 10^{9} \times 1.96 \times 10^{-9} m^{2}$; 1 iii $A = \pi R^{2} = \pi x (25 \times 10^{-6})^{2} = 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 iii $P = \sigma A / 1 = 3.0 \times 10^{6} x 1.96 \times 10^{-9} m^{2}$; 1 any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix A to differes \uparrow anisotropy : stronger axially than transverse - split ends under stress ther neform when stress is removed \land strong sulphur bonds to matrix pull coils back to shape \checkmark 1 1 40 | d | 1.28 M(bits) ✓ ; | 1 | accept 1.22 M(bits) |
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| f $1/l \neq 0 \checkmark$; so $1/v \approx 1/t$ (and $v \approx f$) \checkmark 2 complete argument for both marks10aiany straight line of best fit judged by eye11ii $1.6.0 \pm 0.2 \lor l$ consistent with the y-intercept of their graph11 $2.r = \text{ gradient } / (\pounds - \lor) / 1 / = \lor_{\text{Lost}} / 1 \checkmark$; e.g. = $(6.0 - 0) / 2.0 \checkmark$; = $3.0 \Omega \checkmark$ no working max 1any correct method ; substitution ; evaluation consistent with their graph valuesb(total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; (dissipated) in internal resistor \checkmark ; (dissipated) in internal resistor \checkmark ; (efficiency = $1 \lor / 1 \pounds 2$.0.0 $\Omega \checkmark$ and $P = 1 \lor 2$.3.0.0 $\checkmark \%$; (for the stress the reform $\Lambda = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$; 1 (for the stress is removed / any shape ending at point (300MPa , $25\%) \checkmark$; any shape ending at point (300MPa , $25\%) \checkmark$; any shape ending at point (300MPa , $25\%) \checkmark$; any shape ending at point (300MPa , $25\%) \checkmark$; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends1reward sensible suggestions NOT ductileiisuggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; strong sulphur bonds to matrix pull coils back to shape \checkmark 1iiisuggest: coiled protein molecules can be broken under stress then reform when stress is removed \checkmark ; strong sulphur bonds to matrix pull coils back to shape \checkmark 1iiisuggestions to natrix pull coils back to shape \checkmark 1 </td <td>iii;</td> <td>use of geometry similar triangles / equal angles \checkmark ;</td> <td>1</td> <td>AW</td> | iii; | use of geometry similar triangles / equal angles \checkmark ; | 1 | AW |
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| ii 1.6.0 \pm 0.2 V / consistent with the y-intercept of their graph 2. $r = \text{gradient} / (\varepsilon - V) / I / = V_{LOST} / I \checkmark$; e.g. = (6.0 - 0) / 2.0 \checkmark ; = 3.0 Ω \checkmark no working max 1 b (total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; ci $R = V / I = 3(.0) \Omega \checkmark$ and $P = I V = 3(.0) W \checkmark$; ci (efficiency = $I V / I \mathcal{E} = 3.0 / 6.0$) = 0.5 / 50% \checkmark ; iii (efficiency = $I V / I \mathcal{E} = 3.0 / 6.0$) = 0.5 / 50% \checkmark ; $Power = 2.5 \pm 0.1 W / 1.6 \pm 0.1 W / 1.9 \pm 0.1 W UP \checkmark$ any shape ending at point (250 MPa , 5%) \checkmark ; iii $F = \sigma A / = 3.0 x 10^8$ any arrangement \checkmark ; iii $F = \sigma A / = 3.0 x 10^8 x 1.96 x 10^{-9} \text{ m}^2 \checkmark$; iii $F = \sigma A / = 3.0 x 10^8 x 1.96 x 10^{-9} \text{ m}^2 \checkmark$; iii $F = \sigma A / = 3.0 x 10^8 x 1.96 x 10^{-9} \text{ m}^2 \checkmark$; iii $F = \sigma A / = 3.0 x 10^8 x 1.96 x 10^{-9} (-5.59 / 0.6 N \checkmark$; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends iii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1. 10 10 10 11 10 11 11 11 11 11 | 10ai | any straight line of best fit judged by eye | 1 | |
| $\begin{array}{c c c c c c c c c c c c c c c c c c c $ | ii | 1. 6.0 \pm 0.2 V / consistent with the y-intercept of their | 1 | |
| 2. $r = \text{gradient} / (\pounds - \vee) / I / = V_{\text{LOST}} / I \checkmark$; e.g. $= (6.0 - 0) / 2.0 \checkmark$; $= 3.0 \Omega \checkmark$ no working max 11substitution ; evaluation consistent with their graph valuesb(total) delivered internally and externally / of battery \checkmark ; (dissipated) in internal resistor \checkmark ; $R = V/I = 3(.0) \Omega \checkmark$ and $P = I V = 3(.0) W \checkmark$;1ci(efficiency = $I V / I \mathcal{E} = 3.0 / 6.0) = 0.5 / 50\% \checkmark$; Power $= 2.5 \pm 0.1 W / 1.6 \pm 0.1 W / 1.9 \pm 0.1 W UP \checkmark$ 111a $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^{\circ}$ any arrangement \checkmark ; any shape ending at point (250 MPa , 5%) \checkmark ; any shape ending at point (300MPa , 25%) \checkmark ; any shape ending at point (300MPa , 25%) \land ; any shape ending at point (300MPa , 25%) \land ; any shape ending at point (300MPa , 25%) \land ; any shape strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends1consistent evaluation no line no marksiisuggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1iiisuggest: coiled protein molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1iiisuggestions to matrix pull coils back to shape \checkmark 1iiisuggestions to matrix pull coils back to shape \checkmark 1iiisuggestions to matrix pull coils back to shape \checkmark 1iiisuggestions to matrix pull coils back to shape \checkmark 1 | | graph | 1 | any correct method : |
| e.g. = $(6.0 - 0)/2.0 \checkmark$; = $3.0 \Omega \checkmark$ no working max 1 (total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; ci $R = V/I = \underline{3}(.0) \Omega \checkmark$ and $P = IV = \underline{3}(.0) W \checkmark$; ii (efficiency = $IV/I \mathcal{E} = 3.0/6.0 = 0.5 / 50\% \checkmark$; Power = $2.5 \pm 0.1 W / 1.6 \pm 0.1 W / 1.9 \pm 0.1 W UP \checkmark$ 1 consistent with graph consistent vith graph consistent v | | 2. r = gradient / (ε - V) / I / = V _{LOST} / I \checkmark ; | 2 | substitution : evaluation |
| b (total) delivered internally and externally / of battery \checkmark (dissipated) in internal resistor \checkmark ; $R = V/I = \underline{3}(.0) \Omega \checkmark$ and $P = IV = \underline{3}(.0) W \checkmark$; ii (efficiency = $IV/IE = 3.0/6.0 = 0.5/50\% \checkmark$; $R = V/I = \underline{3}(.0) \Omega \checkmark$ and $P = IV = \underline{3}(.0) W \checkmark$; iii (efficiency = $IV/IE = 3.0/6.0 = 0.5/50\% \checkmark$; $Power = 2.5 \pm 0.1 W/1.6 \pm 0.1 W/1.9 \pm 0.1 W UP \checkmark$ 11 consistent with graph consistent calculation of P from a graph point $11a$ $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^{-9}$ any arrangement \checkmark ; $proportional up to point (250 MPa, 5\%) \checkmark$; $any shape ending at point (300MPa, 25\%) \checkmark$; $A = \pi R^2 = \pi \times (25 \times 10^{-6})^2 = 1.96 \times 10^{-9} m^2 \checkmark$; $F = \sigma A / = 3.0 \times 10^{-6} \times 10^{-9} = 0.59/0.6 N \checkmark$; $any mechanical property \checkmark$ of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | | e.g. = $(6.0 - 0) / 2.0 \checkmark$; = 3.0 $\Omega \checkmark$ no working max 1 | 2 | consistent with their |
| b(total) delivered internally and externally / of battery (dissipated) in internal resistor \checkmark ; (dissipated) in internal resistor \checkmark ; (alssipated) in internal resistor \checkmark ; (bower = 2.5 ± 0.1 W / 1.6 ± 0.1 W / 1.9 ± 0.1 W UP \checkmark (11 (any shape ending at point (250 MPa, 5%) \checkmark ; (any shape ending at point (300MPa, 25%) \checkmark ; (any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres; (alssipated) anisotropy : stronger axially than transverse - split ends1consistent with graph consistent calculation of <i>P</i> from a graph point correct substitution no line no marksiisuggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 10 401 | Ь | | | graph values |
| (dissipated) in internal resistor \checkmark ; $R = V/I = \underline{3}(.0) \ \Omega \checkmark$ and $P = I \lor = \underline{3}(.0)_{-} \lor \checkmark$; ii (efficiency = $I \lor I \lor I \pounds = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$; Power = $2.5 \pm 0.1 \lor V / I \pounds = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$; Power = $2.5 \pm 0.1 \lor V / I \pounds = 3.0 / 6.0$) = $0.5 / 50\% \checkmark$; Power = $2.5 \pm 0.1 \lor V / I \pounds \pm 0.1 \lor U \lor \checkmark$ $1 \pm 0 = 0.05 \times 5.0 \times 10^9$ any arrangement \checkmark ; $1 \pm 0.1 \lor U \lor \checkmark$ $1 \pm 0.1 \lor U \lor \lor \lor$ $1 \pm 0.1 \lor U \lor \lor \lor \lor$ $1 \pm 0.1 \lor \lor$ | D I | (total) delivered internally and externally / of battery 🗸 | 1 | g |
| ci $R = V/I = 3(.0) \Omega \checkmark$ and $P = IV = 3(.0) W \checkmark$; ii (efficiency = $IV/I \pounds = 3.0/6.0 = 0.5/50\% \checkmark$; Power = $2.5 \pm 0.1 W/I \pounds = 3.0/6.0 = 0.5/50\% \checkmark$; Power = $2.5 \pm 0.1 W/I \pounds \pm 0.1 W/I.9 \pm 0.1 W UP \checkmark$ 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 consistent vith graph consistent calculation of P from a graph point 11 construction $(250 MPa, 5\%) \checkmark$; 11 construction $(250 MPa, 25\%) \checkmark$; 11 construction $(250 MPa, 25\%) \checkmark$; 11 evidence of evaluation method; evaluation method; evaluation method; evaluation AW 11 reward other sensible AW reward sensible suggestions NOT ductile 11 ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; 12 weak bonds between coiled molecules can be broken under stress then reform when stress is removed $/$ strong sulphur bonds to matrix pull coils back to shape \checkmark 11 10 40 | | (dissipated) in internal resistor ✓ ; | 1 | or whole circuit |
| ii(efficiency = $IV/IE = 3.0/6.0$) = $0.5/50\% \checkmark$; Power = $2.5 \pm 0.1 W / 1.6 \pm 0.1 W / 1.9 \pm 0.1 W UP \checkmark$ 1consistent with graph consistent calculation of P from a graph point11a $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^{-9}$ any arrangement \checkmark ; proportional up to point (250 MPa, 5%) \checkmark ; any shape ending at point (300MPa, 25%) \checkmark ; any shape ending at point (300MPa, 25%) \checkmark ; is any sh | ci | $R = V/I = \underline{3}(.0) \Omega \checkmark \text{ and } P = I V = \underline{3}(.0) W \checkmark;$ | 2 | NOT in heat |
| ii iii(efficiency = $IV/IE = 3.0/6.0$) = $0.5/50\% \checkmark$; Power = $2.5 \pm 0.1 W/1.6 \pm 0.1 W/1.9 \pm 0.1 W UP \checkmark$ 1 1 1 1 11consistent with graph consistent calculation of P from a graph point11a b proportional up to point (250 MPa, 5%) \checkmark; any shape ending at point (300MPa, 25%) ✓; iii $F = \sigma A / = 3.0 \times 10^{-6} 1^{-2} = 1.96 \times 10^{-9} m^{2} \checkmark;$ iii $F = \sigma A / = 3.0 \times 10^{-8} x 1.96 \times 10^{-9} \checkmark; = 0.59/0.6 N \checkmark;e.g. strength / stiffness : of fibres shifted to matrix /toughness : stress shared by matrix to other fibres /anisotropy : stronger axially than transverse - split ends2reward other sensiblesuggest: coiled protein molecules can uncoil and coil upagain when stress is removed \checkmark;weak bonds between coiled molecules can be brokenunder stress then reform when stress is removed /strong sulphur bonds to matrix pull coils back to shape \checkmark1consistent with graphconsistent calculation ofP from a graph pointcorrect substitutionno line no marksiiiiisuggest: coiled protein molecules can uncoil and coil upagain when stress is removed \checkmark;weak bonds between coiled molecules can be brokenunder stress then reform when stress is removed /strong sulphur bonds to matrix pull coils back to shape \checkmark1iiianisotropy : strong sulphur bonds to matrix pull coils back to shape \checkmark1$ | | | | |
| iii Power = $2.5 \pm 0.1 \text{ W} / 1.6 \pm 0.1 \text{ W} / 1.9 \pm 0.1 \text{ W} \text{ UP } \checkmark$ 11a $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^9$ any arrangement \checkmark ; b proportional up to point (250 MPa, 5%) \checkmark ; any shape ending at point (300MPa, 25%) \checkmark ; ii $A = \pi R^2 = \pi \times (25 \times 10^{-6})^2 = 1.96 \times 10^{-9} \text{ m}^2 \checkmark$; ii $F = \sigma A / = 3.0 \times 10^8 \times 1.96 \times 10^{-9} \checkmark$; = 0.59 / 0.6 N \checkmark ; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix <u>and</u> fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | ii | $(efficiency = IV/IE = 3.0/6.0) = 0.5 / 50\% \checkmark$ | 1 | consistent with graph |
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| 11a $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^9$ any arrangement \checkmark ; proportional up to point (250 MPa, 5%) \checkmark ; any shape ending at point (300MPa, 25%) \checkmark ; $A = \pi R^2 = \pi \times (25 \times 10^{-6})^2 = 1.96 \times 10^{-9} m^2 \checkmark$; $F = \sigma A / = 3.0 \times 10^8 \times 1.96 \times 10^{-9} \checkmark$; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends1correct substitution no line no marksiisuggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1correct substitution no line no marksii $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^{-9}$ (reward sensible suggestions or AW but NOT spring analogy11 | | | 11 | <i>P</i> from a graph point |
| b proportional up to point $(250 \text{ MPa}, 5\%) \checkmark$; any shape ending at point $(300\text{MPa}, 25\%) \checkmark$; ci; $A = \pi R^2 = \pi x (25 \times 10^{-6})^2 = 1.96 \times 10^{-9} \text{m}^2 \checkmark$; ii $F = \sigma A / = 3.0 \times 10^8 \times 1.96 \times 10^{-9} \checkmark$; $= 0.59 / 0.6 \text{ N} \checkmark$; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | 11a | $\sigma = \varepsilon E = 0.05 \times 5.0 \times 10^9$ any arrangement \checkmark ; | 1 | correct substitution |
| any shape ending at point $(300\text{MPa}, 25\%) \checkmark$; $A = \pi R^2 = \pi x (25 \times 10^{-6})^2 = 1.96 \times 10^{-9} \text{m}^2 \checkmark$; $F = \sigma A / = 3.0 \times 10^{-8} \times 1.96 \times 10^{-9} \checkmark$; $0.59 / 0.6 \text{ N} \checkmark$; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | b | proportional up to point (250 MPa , 5%) ✓; | 1 | no line no marks |
| cl; $A = \pi R^2 = \pi x (25 \times 10^{-6})^2 = 1.96 \times 10^{-6} \text{ m}^2 \checkmark$; ii $F = \sigma A / = 3.0 \times 10^{-8} \times 1.96 \times 10^{-9} \checkmark$; = 0.59 / 0.6 N \checkmark ; any mechanical property \checkmark of a composite related to microstructure \checkmark ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | | any shape ending at point (300MPa , 25%) \checkmark ; | 1 | avidance of avaluation |
| II $F = \sigma A / = 3.0 \times 10^{-\sigma} \times 1.96 \times 10^{-\sigma} \checkmark ;= 0.59 / 0.6 N \checkmark ;$ any mechanical property ✓ of a composite related to microstructure ✓ ; explain by ref to matrix and fibres ; e.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split ends2Internol , evaluation AW reward other sensible physics suggestions NOT ductileiisuggest: coiled protein molecules can uncoil and coil up again when stress is removed ✓ ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape ✓1Internol , evaluation AW reward other sensible physics suggestions NOT ductile | CI; | $A = \pi R^{2} = \pi x (25 \times 10^{-6})^{2} = 1.96 \times 10^{-6} \text{ m}^{2} \checkmark ;$ | | mothed : evaluation |
| di any mechanical property ✓ of a composite related to nicrostructure ✓; explain by ref to matrix and fibres; reward other sensible e.g. strength / stiffness : of fibres shifted to matrix / reward other sensible physics suggestions iii suggest: coiled protein molecules can uncoil and coil up reward sensible iii suggest: coiled protein molecules can uncoil and coil up 1 iii suggest: coiled protein molecules can uncoil and coil up 1 iii suggest: coiled protein molecules can be broken 1 under stress then reform when stress is removed ✓; 1 strong sulphur bonds to matrix pull coils back to shape ✓ 1 10 40 | . 11 | $F = \sigma A / = 3.0 \times 10^{\circ} \times 1.96 \times 10^{\circ} \checkmark = 0.59 / 0.6 \text{ N} \checkmark ;$ | 2 | |
| undermicrostructure \checkmark ; explain by ref to matrix and nores ;undere.g. strength / stiffness : of fibres shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsnore stress is removed \checkmark ;nore stress is removed \checkmark ;iisuggest: coiled protein molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1nore stress then reform when stress is removed / 10 | di | any mechanical property ✓ of a composite related to | 2 | reward other sensible |
| e.g. strength / stimless . Of holes shifted to matrix / toughness : stress shared by matrix to other fibres / anisotropy : stronger axially than transverse - split endsNOT ductileiisuggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1NOT ductile10 401 | u | microstructure , explain by rel to matrix and libres , | - | physics suggestions |
| ii anisotropy : stronger axially than transverse - split ends suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | | toughness : stress shared by matrix to other fibres / | | NOT ductile |
| ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | | anisotropy : stronger axially than transverse - split ends | | |
| ii suggest: coiled protein molecules can uncoil and coil up again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 40 | | anice opproved and an anice of the office of the | | |
| ii again when stress is removed \checkmark ; weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark $\frac{1}{10}$ | | suggest: coiled protein molecules can uncoil and coil up | | reward sensible |
| weak bonds between coiled molecules can be broken under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape \checkmark 1 10 40 | ii | again when stress is removed \checkmark ; | 1 | suggestions or AW but |
| under stress then reform when stress is removed / strong sulphur bonds to matrix pull coils back to shape ✓ $1 - 1 - 10$ 40 | | weak bonds between coiled molecules can be broken | | NOT spring analogy |
| strong sulphur bonds to matrix pull coils back to shape ✓ 10 10 40 | | under stress then reform when stress is removed / | 4 | |
| 40 | | strong sulphur bonds to matrix pull coils back to shape \checkmark | 10 | |
| | | | 40 | |

Final Mark Scheme

| | Total section B | | |
|------|--|-------|---|
| Qn | Expected Answers | Marks | Additional guidance |
| 12ai | Section C e.g. text / logos ✓ ; by FAX✓ ; | 2 | |
| ii | a frequency estimate \checkmark 64 kHz (allow kbits per s) \checkmark ; frequency at which binary bits of information are transmitted down the telephone line from transmitting to | 2 | sensible for example chosen with unit accept speech / carrier |
| | receiving FAX machines ✓ | 1 | / sampling frequencies |
| iii | higher f enables greater rate of information transfer \checkmark | 1 | NOT more data |
| b | 1/2/3 style ✓ ✓ ✓ analogue – continuously variable signal digital – two level / binary signal accept correct diagrams or explanation to max 3 | 3 | AW |
| C | ady - communication on the move / worldwide \checkmark : | 1 | allow any sensible |
| Ū | exp – emergency services can be contacted immediately at an accident \checkmark ; | 1 | justified cases of making physics connect |
| | disadv – mobile phones ringing in trains / concerts \checkmark ; exp – annoyance to other passengers / audience \checkmark ; | 1 | |
| | Total | 13 | |
| 13a | e.g. light intensity ✓; LDR ✓ | 2 | allow amount of fuel |
| Ь | circuit diagram 1/2/3 style ✓ ✓ ✓ penalise incorrect circuit symbols | 3 | full marks for active sensor circuit with suitable output monitor |
| ci | e.g. vary light intensity and measure (against a known standard / digital luxmeter) ; | | vary input and measure |
| | plot graph of output p.d. against intensity ; gradient of graph / AW for sensitivity | | correct plot measure sensitivity |
| | OR 1/2/3 style ✓ ✓ ✓ | 3 | |
| ii | e.g. 3 ✓ mV per lux / mV per W m⁻² ;✓ | 2 | unit must relate to b / c value plus incorrect unit |
| iii | any change to fixed resistor in potential divider / | 1 | easy first mark |
| | to give appropriate output alteration ; to increase range of output (for similar input change) OR $1/2/3$ style $\checkmark \checkmark \checkmark$ | 1 | look back to circuit tough third mark other approaches |
| | Total | 13 | |
| | Quality of written communication | _4_ | |
| | Total section C | 30 | |

QoWC Marking quality of written communication

The appropriate mark (0-4) should be awarded based on the candidate's quality of written communication in Section C of the paper.

4 max The candidate will express complex ideas extremely clearly and fluently. Answers are structured logically and concisely, so that the candidate communicates effectively. Information is presented in the most appropriate form (which may include graphs, diagrams or charts where their use would enhance communication). The candidate spells, punctuates and uses the rules of grammar with almost faultless accuracy, deploying a wide range of grammatical constructions and specialist terms.

3 The candidate will express moderately complex ideas clearly and reasonably fluently. Answers are structured logically and concisely, so that the candidate generally communicates effectively. Information is not always presented in the most appropriate form. The candidate spells, punctuates and uses the rules of grammar with reasonable accuracy; a range of specialist terms are used appropriately.

2 The candidate will express moderately complex ideas fairly clearly but not always fluently. Answers may not be structured clearly. The candidate spells, punctuates and uses the rules of grammar with some errors; a limited range of specialist terms are used appropriately.

1 The candidate will express simple ideas clearly, but may be imprecise and awkward in dealing with complex or subtle concepts. Arguments may be of doubtful relevance or obscurely presented. Errors in grammar, punctuation and spelling may be noticeable and intrusive, suggesting weakness in these areas.

0 The candidate is unable to express simple ideas clearly; there are severe shortcomings in the organisation and presentation of the answer, leading to a failure to communicate knowledge and ideas. There are significant errors in the use of language which makes the candidate's meaning uncertain.

Final Mark Scheme

| Qn | Expected Answers | Marks | Additional guidance |
|-------|---|-------|---|
| | Section A | | |
| 1 (a) | 5 x 10 ⁻⁴ (m) ✓ | 1 | |
| 1 (b) | 500 (nm) 🖌 | 1 | or 5 x 10² (nm) |
| 2 | $(3.0)^2/(1.5)^2$ or 9/2.25 or $2^2 \checkmark$ ratio = 4 \checkmark | 2 | for ratio = 4 ✓✓ |
| 3 (a) | t = 2s/(u + v) ✓ t = (v – u)/a ✓ | 2 | |
| 3(b) | $(2s/(u + v) = (v - u)/a)$ to $2as = (uv - u^2 + v^2 - uv) \checkmark$ or $2as = v^2 - u^2$ | 1 | not 2as = $u^2 - v^2$ |
| 4 | 2 correct additional points (other than 0,0) $\checkmark \checkmark$ <u>appropriate</u> line through the points plotted and (0,0) \checkmark | 3 | error in point plotted –1 judge line through |
| 5(a) | $1.0 \times 10^{15} (Hz) \checkmark (1.0 Hz = zero)$ | 1 | points <u>piotted</u> |
| 5(b) | below f_o no electrons (above f_o you get electrons) \checkmark min f corresponds to min photon energy = hf \checkmark | 2 | |
| 5(c) | $(10 \times 10^{-19})/(1.5 \times 10^{15}) = 6.7 \times 10^{-34} \checkmark (J s)$ penalise more than 3 sf | 1 | accept 1 s.f. |
| 6 | Line/curve up from (0,0) to $t_1 \checkmark$ plateau from t_1 to $t_2 \checkmark$ Line/curve down from plateau to $(t_3,0) \checkmark$ | 3 | |
| 7(a) | 90° or 270° or $\pi/2$ or $3\pi/2$ or $\frac{1}{4}$ of a cycle \checkmark (not $\lambda/4$) | 1 | |
| 7(b) | A at 6 o'clock ✓ B at 9 o'clock ✓ | 2 | |
| | Section A total | 20 | |
| | | | |
| | | | |
| | | | |

| Qn | Expected Answers | Marks | Additional guidance |
|-------------|--|-------|--|
| | Section B | | |
| 8 (a)(i) | correct standing wave \checkmark one A and one N labelled \checkmark | 2 | |
| (ii) | clear method \checkmark showing $I_2 - I_1 = \lambda/2$ | 1 | |
| (iii) 1 | $0.506 - 0.170 = \lambda/2 \checkmark \lambda = 0.672 \text{ (m)} \checkmark (0.67)$ | 2 | not by v = $f\lambda$ here, must be using $h = h = \lambda/2$ |
| (iii) 2 | $v = 500 \times 0.672 \checkmark = 336 \text{ m s}^{-1} \checkmark (\text{ecf from (a)(iii)})$ accept 340 m s ⁻¹ | 2 | 0.67 gives 335 |
| (b) | smaller wavelength ✓ smaller distances (to measure) ✓ less accuracy in the measurements ✓ | 3 | |
| | | | |
| | total | 10 | |
| | | | |
| 9 (a)(i) | orange; brighter; broader(wider) ✓ ✓ | 2 | maximum 2 marks v |
| (ii) | 2 wavelengths (or frequencies) ✓ | 1 | |
| (iii) | Shorter $\lambda \checkmark \sin\theta = \lambda/d$ idea \checkmark | 2 | or rotating phasors argument |
| (iv) | both wavelengths contribute in phase (AW) \checkmark | 1 | or rotating phasors argument |
| (b) (i) | larger distance from orange ✓ approx double ✓ | 2 | see acceptable limits |
| (ii) | 'd' (slit separation) is halved (or less) \checkmark sin θ = λ /d idea \checkmark (or bigger angle to give same path diff) | 2 | rotating phasors idea |
| | | | |
| | total | 10 | |
| | | | |
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| Qn | Expected Answers | Marks | Additional guidance |
|--------------|--|-------|---|
| | | | |
| 10 (a)(i) | 17 cos 30 or 17 sin 60√ (= 14.7 m s⁻¹) | 1 | |
| (ii) | accelerating / because of gravity or gravity reduces vertical component | 1 | |
| (iii) | s = $(14.7x1.5) - \frac{1}{2}x9.8x(1.5)^2 \checkmark_m \checkmark_s = 11 \text{ m} \checkmark \text{ (approx)}$ (g = 10 gives 10.83) | 3 | or by $v^2 = u^2 - 2as$ or s = (u + v)t/2 |
| (b)(i) | time less \checkmark smaller vertical height (or smaller v _Y) \checkmark (or horizontal velocity greater, distance same (t = s/v)) | 2 | |
| (ii) | Horiz component of velocity greater✓ but time less and s = vt ✓ | 2 | |
| (iii) | first ball since it will bounce more \checkmark , less friction \checkmark (<u>or</u> second ball because horizontal component of velocity is greater \checkmark so friction takes 'longer' to stop it \checkmark) | 2 | 2 marks for (i) a plausible statement, (ii) supported by the physics |
| | total | 11 | |
| 11 (a)(i) | 1 - 2.0 (km h⁻¹) ✓ 2 +8.0(km h⁻¹) ✓ | 2 | For omitting/confusing + and – signs (max 1) |
| (ii) | Using t = $x/v \checkmark 2/2 + 2/8 \checkmark$ (= 1.25 hr) no ecf here | 2 | |
| (b)(i) | correct drawing/sketch of velocity vectors \checkmark accuracy of scale giving 37° or sin θ = 0.6 = 37° \checkmark | 2 | |
| (ii) | Using accurate scale drawing in (b)(i) \checkmark = 4.0 km h ⁻¹ \checkmark (or by trig / pythgoras \checkmark answer shown \checkmark) | 2 | |
| (c) | for showing position of P is I km from A and B \checkmark for scale drawing or tan θ = 0.5 \checkmark (θ = 26.6) | 2 | |
| | total | 10 | |
| | Section B total | 41 | |
| | | | |
| | | | |
| | | | |

| Qn | Expected Answers | Marks | Additional guidance |
|--------------|--|-------|--|
| | Section C | | |
| 12 (a) | for stating a quantum phenomenon | 1 | see supplementary sheets |
| (b) | essentially correct $\checkmark \checkmark \checkmark$ satisfactory but with some significant error/omission $\checkmark \checkmark$ | 3 | |
| (c) | for observations that could be made with the apparatus described up to $4 \checkmark_0 \checkmark_0 \checkmark_0 \checkmark_0$ | 4 | mark \checkmark_{o} and \checkmark_{e} in both (c) and (d) |
| (d) | for points of explanation $\checkmark_e \checkmark_e \checkmark_e \checkmark_e$ (not all points of explanation will necessarily be quantum) | 4 | must be rooted in a quantum explanation |
| | total | 12 | |
| 13 (a)(i) | for stating type of wave ✓ | 1 | see supplementary sheets |
| (a) (ii) | sensible order of magnitude of wavelength \checkmark sensible order of magnitude of velocity \checkmark | 2 | I |
| (b) | essentially correct ✓✓✓ satisfactory with some significant error/omission ✓✓ some attempt made ✓ | 3 | |
| (c) | 1 enough detail to perform operation ✓ | 1 | |
| (d) | for three salient observations that could be made $\checkmark \checkmark \checkmark$ | 3 | |
| | for explaining each of the observations described $\checkmark\checkmark\checkmark$ | 3 | Bright |
| | 4-4-1 | 12 | |
| | | 15 | |
| | Quality of Written Communication | 4 | |
| | Section C total | 29 | |
| | Total for paper | 90 | |

| Question | Expected Answers | Marks |
|----------------------------|--|-------------|
| 1 (a) (b) | 10 ⁻²¹ J ✓ 10 ⁻¹⁵ J ✓ | 1 |
| 2 (a) (b) | factor =440/122✓ = 3.6✓ (two marks for answer) light from more distant objects has travelled for a greater time/distance✓ so more expansion. ✓ AW (penalise lack of clarity) | 2 2 |
| 3 (a) | valid test on two or more pairs of data \checkmark (showing constant ratio) valid conclusion \checkmark OR: linear graph and clear argument/log graph \checkmark quality \checkmark e.g. radioactive decay, decay of charge on capacitor \checkmark | 2 |
| (b) | | 1 |
| | $pV = nRT \checkmark V = nRT/p = 2 \times 8.3 \times 310/1.5 \times 10^5 = 3.4 \times 10^{-2} \text{ m}^3 \checkmark$ | 2 |
| 4 | | 2 |
| | $k = F/x = 9.81 \times 0.4/22 \times 10^{-3} \checkmark = 178 \text{ N m}^{-1} \checkmark \text{ ORA penalise lack of quality}$ | |
| 5 (a) | $f = (1/2 \pi) \cdot (k/m)^{\frac{1}{2}} \checkmark = 0.16 \times (180/0.4)^{\frac{1}{2}} \checkmark = 3.4 \text{ Hz} \checkmark \text{ ecf}$ | 2 |
| (b) | (If time period used without frequency calculation one mark only) | 3 |
| 6 (a) | 2.7 x 7.3 = 19.7 kg m s ⁻¹ \checkmark force (on clown) = rate of change of momentum \checkmark , and clear Newton 3 argument relating to clown and water. \checkmark | 1 2 |
| (c) | of momentum per second is greater than 19.7 N so force on clown increased. ✓ Section A total 21 | 2 |
| | | |
| 7 (a) (i) (ii) (iii) | $E = \frac{1}{2} C V^2 = \frac{1}{2} \times 200 \times 10^{-6} \times 390^2 \checkmark = 15 (.2) J \checkmark$ P = 15(.2)/0.01 \sqrt{ = 1500 W} ecf Pd or current not constant over time \sqrt{ so the power (energy per second) is falling \sqrt{.} | 2 2 2 |
| | 5RC = 0.01 R = 0.01/(5 x 200 x 10 ⁻⁶) \checkmark = 10 Ω . | |
| (b) | E α V ² V α E ^{1/2} \checkmark therefore factor increase is $\sqrt{2} \checkmark$ or by calculation of new value | 2 |
| (c) | ✓ leading to factor ✓ ecf a (I) | 2 |
| (d) | Lower pd across single capacitor \checkmark so less chance of breakdown. \checkmark or sensible alternatives leading to logical conclusion. (e.g.; smaller size leading to easier implantation) | 2 |
| | | |

| 8(a) (i) | Greatest displacement \checkmark from equilibrium position \checkmark (can use diagram). | 2 |
|------------------------------|--|------------------|
| (ii) (iii) (iv) (v) | 0 mm \checkmark 0 m s ⁻² \checkmark a = (-) $4\pi^2 f^2 x = (-) 4\pi^2 x 100 x 0.035 \checkmark = 138 m s^{-2} \checkmark$ SF penalty (≤ 3 sf OK) either calculate force due to oscillation \checkmark and compare with weight \checkmark or compare values of accelerations \checkmark and link to accelerating force \checkmark ecf. | 1 1 2 2 |
| (b) (i) (ii) | Natural frequency of aerial \checkmark same as driving/satellite frequency \checkmark AW Sensible change \checkmark to damp or shift resonant frequency \checkmark . | 2 2 |
| 9(a) | Calculating energy as 108 kJ (can be implicit) ✓ Temp change = 108000/(0.4 x 4200) ✓ = 65° C ✓ . | 3 |
| (b) | As T increases (e ^{-E/kT} gets bigger) BF bigger ✓ hence greater chance/proportion of molecules entering vapour state ✓. AW | 2 |
| (c) (i) | 1 st marking point: As the number of molecules in the vapour increases so does the number of collisions (per second) OR Pressure = Force / Area argument \checkmark 2 nd marking point: consideration of rate of change of momentum on collision (with the lid) \checkmark . | 2 |
| | OR explanation based on gas equations \checkmark stating constant volume \checkmark | |
| (c)(ii) | Faster collisions with lid (giving greater change of momentum per collision) \checkmark more collisions per unit time \checkmark | 2 |
| | OR explanation based on gas equations \checkmark stating constant volume \checkmark | |
| (c) (iii) | Sensible comment relating to lid blowing off/soup all over the microwave \checkmark . | 1 |

| | | 1 |
|---------|---|---------|
| 10 (a) | Straight line \checkmark through origin \checkmark | 2 |
| (b)(i) | $F = m a = m x v^2 / R \checkmark$ | 1 |
| (ii) | F = (-)G Mm/R² ✓ | 1 |
| · (iii) | $mv^2/R = G Mm/R^2 \checkmark$ | 1 |
| (iv) | $(2\pi R/T)^2 R=GM \checkmark$ worked through to given equation \checkmark (or alternative route) $\checkmark \checkmark$ | 2 |
| (v) | $M_{s} = 4 \pi^{2} (1.5 \times 10^{11})^{3} / 6.7 \times 10^{-11} \times (3.2 \times 10^{7})^{2} \checkmark = 1.94 \times 10^{30} \checkmark$ | 2 |
| (c) | suggestion linked to \checkmark sensible explanation \checkmark . | 2 |
| | | |
| | QoWC Section B total | 4 49 |
| | | |

| Question | Expected Answer | Mark |
|----------|---|------|
| 1 (a) | 50 | 1 |
| 1 (b) | Calculate: $\frac{V_1}{V_2} = \frac{n_1}{n_2}$ (eor) | 1 |
| | $n_2 = 1840 \times (6/230) = 48$ (award [2] for correct answer) | |
| 2 | rearranged formula ($k = Vr/Q$), Q is C, r is m | 1 |
| | V has units of J C ⁻¹ (wtte) (so units of <i>k</i> are J C ⁻¹ m C ⁻¹) accept reverse argument | 1 |
| 3 (a) | smooth curve downwards (by myopic eye) emerges between 0 and 2.5 cm left of vertical line through nucleus | 1 |
| | P | 1 |
| 3 (b) | В | |

| Question | Expected Answer | Mark |
|----------|--|--------|
| 4 (a) | $(30 \times 10^{-3} \times 40 \times 80 = 96)$ C | 1 |
| 4 (b) | risk = $3 \times 30 \times 10^{-3} \times 40 = 3.6 \%$ (accept 0.036 with % crossed out). | 1 |
| 5 (a) | 10 ⁻¹⁴ m | 1 |
| 5 (b) | 10 ⁻¹⁸ C | 1 |
| 6 (a) | horizontal line touching X (by eye) arrow from right to left \leftarrow pointing towards charged conductor | 1 |
| 6 (b) | spacing between equipotentials/circles/lines increases (with increasing distance) (ora) answer in terms field lines worth [0] | 1 |
| 7 (a) | neutrons (accept circled in list) | 1 |
| 7 (b) | C (accept positron or ring around positron) | 1 |
| 8 (a) | Calculate: $E = kQ/r^2$ (eor) $Q = Er^2/k = 5 \times 10^6 \times 0.025^2 / 9 \times 10^9 = 3.5 \times 10^{-7}$ C correct answer worth [2] (accept 3×10^{-7}) | 1 1 |
| 8 (b) | any of the following air becomes a conductor / breaks down charge/current leaks from surface of conductor air molecules/atoms are ionised by the electric field sparks carry charge away from conductor field affects conductance/resistance of air stray ions neutralise charge | 1 |

| Question | Expected Answer | Mark |
|----------|--|--------|
| 9(a)(i) | continuous loop passing through the letters N and S (by eye) | 1 |
| | threading the coil, mostly within the iron core | 1 |
| 9(a)(ii) | any of the following, maximum [2] (wtte) guides/conducts flux lines (through coil) / links flux to coil becomes magnetised by rotor easy to magnetise / demagnetise / realign magnetic dipoles (wtte) increases the strength of the field / more flux (in the coil) high permeance / permeability low remanence / hysteresis / energy loss (wtte) provides magnetic circuit (for flux) Iron is a magnetic material worth [0] | 2 |
| 9(b)(i) | sinusoidal shape, correct period, constant amplitude, at least one | 1 |
| | correct phase, either $\pi/2$ ahead or behind | 1 |
| 9(b)(ii) | Show: (revolutions per second) = 1/15×10 ⁻³ = <u>67</u> NOT 66 or 70 (accept reverse argument (14 ms) for full marks) | 1 1 |
| 9(c) | any of the following, maximum [3] reduces eddy currents (accepts stops) caused by changes of flux (linkage) (in the core) by increasing resistance / decreasing conductance of the core eddy currents create magnetic field / flux which (partially) cancel out field / flux of rotor (i.e. Lenz's Law) eddy currents reduce the field / flux (in the coil/core) eddy currents dissipate (heat) energy in the core (laminations) increase flux / flux density / flux linkage (in coil/core) back emf is neutral | 3 |
| | | |

| Question | Expected Answer | Mark |
|------------|---|------|
| 10(a)(i) | Calculate: proton number = 94 | 1 |
| | neutron number = $239 - 94 = 145$ | 1 |
| | ect incorrect proton or neutron number: 4 + 27 + 4 + 27 = 2 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 25 + 200 + 4 + 200 + | 1 |
| | total mass = $94 \times 1.073 \times 10^{-7} + 145 \times 1.074 \times 10^{-7} = 3.999 \times 10^{-9}$ kg | • |
| | accept $4(.000) \times 10^{-2.5}$ kg and no incorrect calculation for [3] | |
| | accept 5.573×10^{-25} for [2] i.e. 239 neutrons and 94 protons | |
| | accept 3.994×10^{-25} for [1] i.e. 94 neutrons and 145 protons | |
| | 4.001×10-25 worth [0] i.e. 239 neutrons | : |
| | 3.998×10-23 Worth [0] I.e. 239 protons | |
| 10(a)(ii) | any of the following, maximum [2] | 2 |
| | difference caused by <u>binding energy</u> | |
| | (strong) forces/bonds hold neutrons and protons in nucleus | |
| | • particles have less energy/mass in the nucleus (ora) | |
| | • $E = mc^2$ (wtte) | |
| | do work to separate the particles in a nucleus | |
| 10(b)(i) | $1/2 = 2 \sqrt{7} / 4 \sqrt{10-15}$ | |
| 10(0)(1) | $\lambda = 4 + 7.4 \times 10^{-15} = 2.06 \times 10^{-14} \text{ m} (= 2 \times 10^{-14} \text{ m})$ | 1 |
| | $\chi = 4 \times 7.4 \times 10^{-10} = 2.96 \times 10^{-11} \text{ m} (= 3 \times 10^{-11} \text{ m})$ | |
| 10(b)(ii) | Show: $\lambda = h/p$ | 0 |
| | $p = h/\lambda$ (eor for rearranged formula) | 1 |
| | $p = 6.6 \times 10^{-34} / 2.96 \times 10^{-14} = 2.23 \times 10^{-20} \text{ N s (or kg m s}^{-1})$ | 1 |
| | ecf incorrect λ : 2.20×10-20 N s for 3×10-14 m | |
| | accept reverse calculation for [2] | |
| | | |
| 10(b)(iii) | Calculate: EITHER $E_{\rm k} = p^2/2m$ OR $E_{\rm k} = mv^2/2$, $p = mv$ | 1 |
| | $E_{\rm k} = (2.2 \times 10^{-20})^2 / 2 \times 6.7 \times 10^{-27} = 3.6 \times 10^{-14} {\rm J}$ | 1 |
| | ACCEPT 3 7×10-14 NOT 4×10-14 | |
| | $ACCEPT 3(0) \times 10^{-14}$ I for 2×10-20 N s | |
| | | |

| Question | Expected Answer | Mark |
|----------|---|------|
| 10(c) | plausible suggestion of mechanism | 1 |
| | argument linking mechanism to decay | 1 |
| | e.g. | |
| | some energy (levels) above the ground state | |
| | give the particle enough energy to escape | |
| | collisions (with other particles) in nucleus | |
| | gives alpha particle enough energy to escape | |
| | when alpha particle is raised above ground state | |
| | it may be able to tunnel through the walls of the well | |
| | particle has finite chance of being outside nucleus because standing wave extends beyond the potential well | |

| Question | Expected Answer | Mark |
|------------|--|------------------|
| 11(a)(i) | mass numbers correct charge numbers correct $^{239}_{94}Pu \rightarrow ^{235}_{92}U + ^{4}_{2}He$ | 1 1 |
| 11(a)(ii) | Show: $\lambda = 0.693/T_{1/2}$ $\lambda = 0.693/7.6 \times 10^{11} = 9.12 \times 10^{-13} \text{ s}^{-1}$ ecf incorrect decay constant: $A = \lambda N$ $A = 9.12 \times 10^{-13} \times 2.5 \times 10^{14} = 228$ Bq (accept 230) (which is >> 1 Bq) accept reverse argument showing 1.1×10^{12} nuclei for 1 Bq for [2] | 0 1 0 1 |
| 11(a)(iii) | $m = 239 \times 1.7 \times 10^{-27} \times 2.5 \times 10^{14} = 1(.0) \times 10^{-10} \text{ kg}$ | 1 |
| 11(a)(iv) | any of the following, maximum [3] no risk from alpha particles from outside the body (wtte) alpha particles have short range / low penetration produce very heavy ionisation / high quality factor because of their high charge / mass can damage cells so that they <u>mutate</u> (wtte) NOT kill cells only a few cells/local tissue is irradiated (wtte) leading to a high dose for that tissue reference to beta particles / gamma photons are neutral | 3 |
| 11(b)(i) | 8 | 1 |
| 11(b)(ii) | Calculate: $E_e = kQq/r$ $E_e = 9 \times 10^9 \times 1.5 \times 10^{-17} \times 1.6 \times 10^{-19} / 7.4 \times 10^{-14} = 2.9 \times 10^{-13} \text{ J}$ | 1 |

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| Question | Expected Answer | Mark |
|-----------|---|------|
| 12(a) | Calculate: $F = Bqv$ | 0 |
| | $v = F/Bq = 9.6 \times 10^{-23} / 0.12 \times 1.6 \times 10^{-19}$ | |
| | = 5.0×10 ⁻³ | 1 |
| | m s ⁻¹ | |
| | ACCEPT 5 mm s ⁻¹ , 0.5 cm s ⁻¹ | |
| 12(b) | any of the following, maximum [2] magnetic force at right angles to field direction magnetic force at right angles to motion <u>electrons</u> (NOT charge) pushed to bottom edge of strip leaving positive <u>ions</u> at the top edge of the strip (ACCEPT <u>holes</u> pushed to the top) | 2 |
| 12(c)(i) | vertical, evenly spaced lines in field region, at least three | 1 |
| | downward arrow \downarrow on each line | 1 |
| 12(c)(ii) | Show: EITHER F = eV/d OR E = V/d, F = eE | 1 |
| | $F = 1.6 \times 10^{-19} \times 9.6 \times 10^{-6} / 16 \times 10^{-3} = (9.6 \times 10^{-23} \text{ N})$ | 1 |
| 12(d) | Show: <i>F</i> _m = <i>Bev, F</i> _e = <i>eE</i> so <i>Bev</i> = <i>eE</i> | 1 |
| | Bev = eV/d | 1. |
| | V = Bvd (= constant × B) | 1 |
| | watch for confused v and V | |
| | Quality of Written Communication | 4 |

| Qn | Expected Answers | Marks | Additional guidance |
|-------|---|--------|---|
| 1 (a) | (i) 5.4 MeV = $5.4 \times 10^{6} \text{ eV } \checkmark$ = $5.4 \times 10^{6} \times 1.6 \times 10^{-19} \text{ J} = 8.6 \times 10^{-13} \text{ J} \checkmark$ | 2 | |
| | (ii) $\frac{1}{2}mv^2 = 8.6 \times 10^{-13} \text{ J} \Rightarrow v = \sqrt{\frac{2 \times 8.6 \times 10^{-13}}{6.6 \times 10^{-27}}} \sqrt{m}$ = 1.6 × 10 ⁷ m s ⁻¹ \sqrt{e} | 2 | Can use 9× 10 ⁻¹³ J ora from v=2× 10 ⁷ m s ⁻¹ |
| (b) | (i) 206✓ | 1 | |
| | (ii) 0=206v + 4× 2 × 10 ⁷ m s ⁻¹ $\checkmark \Rightarrow$ v = (-) 3.9× 10 ⁵ m s ⁻¹ \checkmark | 2 | First mark is application of conservation of momentum Using 1.6×10^7 m s ⁻¹ \Rightarrow $v = 3.1 \times 10^5$ m s ⁻¹ |
| | (iii) v smaller, m bigger \checkmark (this factor occurs) twice in v^2 and once in m so $\frac{1}{2}mv^2$ smaller \checkmark | 2 | Can use masses in kg Can refer to same <i>p to</i> justify <i>m/v</i> relationship Arithmetic method OK |
| 2 (a) | Reference to proton-electron (beta) charge balance√ | 1 | 83 = 84 -1+0 is ✓ |
| (b) | Not ionising (and detectors observe ionisation)✓ | 1 | |
| (c) | (i) $\Delta m = 209.93845 - 209.93666 - 0.00055 = 0.00124 \text{ v}$ = 0.00124 × 1.7×10 ⁻²⁷ kg = 2.11×10 ⁻³⁰ kg \checkmark (2.something small ×10 ⁻³⁰ kg allows for rounding error) (ii) $E = mc^2 = 2.11 \times 10^{-30} \times (3.0 \times 10^8)^2 = 1.9 \times 10^{-13} \text{ J} \sqrt{m} \sqrt{e}$ | 2 2 | Ecf possible here |
| 3 (a) | annihilation produces 2 photons in opposite directions ✓ | 1 | Could refer to coincidence counting |
| (b) | Neutron slower than positron / neutron less easily absorbed than positron/ Cd nuclei rarer than electrons ✓ | 1 | Any reasonable suggestion |
| (c) | (i) (Counts of) photon pair (+ single photon just after) ✓ (ii) Background radiation/cosmic rays/stray photons\ ✓ | 1 1 | Allow neutrinos |
| (d) | Reduces noise/background radiation ✓ By absorb all cosmic radiation/AW ✓ | 2 | Must specify/imply radiation from space not rocks for second ✓. |

| Qn | Expected Answers | Marks | Additional guidance |
|-------|---|--------|---|
| 4 (a) | (i) number (of neutrinos) per (unit) time \checkmark per (unit) area \checkmark (ii) flux = 2 × 10 ³⁸ /2.8 × 10 ²³ m ² = 7.1×10 ¹⁴ m ⁻² s ⁻¹ \checkmark m \checkmark e | 2 2 | or per m ² |
| (b) | (i) Area between 0.2 and 1.2 m ² \checkmark (ii) Number = area×7.1×10 ¹⁴ m ⁻² s ⁻¹ \approx 4×10 ¹⁴ s ⁻¹ \checkmark m \checkmark e (iii) Number absorbed s ⁻¹ = 4×10 ¹⁴ /10 ¹⁸ \checkmark = 4×10 ⁻⁴ so energy absorbed/year = 4×10 ⁻⁴ ×3.2×10 ⁷ ×1.6×10 ⁻¹³ J = 2.1×10 ⁻⁹ J \checkmark | 1 2 | sfe for > 2 sf can use7×10 ¹⁴ m ⁻² s ⁻¹ ecf for neutrino numbers and area |
| | absorbed dose= 2.1×10^{-9} J /65 kg = $3 \times 10^{-11} \checkmark$ Gy/grays/J kg ⁻¹ \checkmark (iv) Insignificant dose/ low quality factor/not much energy absorbed/ weakly interacting \checkmark | 4 | |
| 5 (a) | (i) steadily increasing line of (roughly) constant gradient√ (ii) increases from 0 and (quickly) levels off√ | 1 | Allow large random variations (see (d)) |
| (b) | <i>T</i> ^½ = ln 2/2.3×10 ⁻⁷ s ⁻¹ =3.0×10 ⁶ s (= 34.9 days) ≈ 2.6 ×10 ⁶ s ✓m✓e | 2 | A stated or implied comparison with a month is needed. |
| (c) | Low count rate hard to distinguish from background / tiny amount of Ar compared with the vast volume of $C_2Cl_4 \checkmark$ | 1 | |
| (d) | neutrino interactions are infrequent and random \checkmark ; Ar-37 decays also infrequent and random \checkmark ; small counts tend to fluctuate \checkmark | 2 | Any two relevant points; may refer to elliptical orbit of Earth or to neutrino oscillations |
| 6(a) | Distance = 3.0 × 10 ⁸ × 3.2 × 10 ⁷ × 40 000 m = 3.8×10 ²⁰ m ✓ m✓ e | 2 | |
| (b) | Continual absorption and emission✓ random changes in direction ✓ | 2 | Can compare with gas diffusion for one ✓ |
| (c) | T 1000 (actually 1034) × higher $\checkmark \Rightarrow$ E 1000× higher $\checkmark \Rightarrow$ f 1000× higher \checkmark | 3 | Arithmetically: <i>E=kT</i> calc ✓, <i>E=hf</i> calc ✓ and ratio ✓ |
| (d) | $\sqrt{NL} = 2.0 \times 10^8 \text{ m} \implies NL^2 = 4.0 \times 10^{16} \text{ m}^2$ $NL = 4.0 \times 10^{20} \text{ m} \implies NL^2 / NL = L = 4.0 \times 10^{16} \text{ m}^2 / 4.0 \times 10^{20} \text{ m}$ $= 1.0 \times 10^{-4} \text{m} \sqrt{m} \sqrt{m} \sqrt{e}$ | 3 | ✓ m for combining two equations ✓ m for rearranging. L « solar radius for ✓ e |

| 7 (a) | iron nucleus has most negative binding energy/ greatest mass defect/is most stable \checkmark so no stability gained by further fusion \checkmark | 2 | |
|-------|---|--------|--|
| (b) | (i) time delay of 340 000 years (impossibly huge) ✓ (ii) Hubble's Law / cosmological redshift concerns separate groups of galaxies ✓ this galaxy (Larger Magellanic Cloud) is gravitationally bound to ours/AW ✓ | 1 | (ii) Allow: supernova's galaxy relatively close√ so small redshift√ |
| (c) | As star explodes, matter ejected (at exceedingly high speed) so less obstruction for photons | 1 | |
| 8 (a) | (i) $Vt = 10 \times 230 \times 3 \times 60 \text{ J} = 4.1 \times 10^5 \text{ J} \approx 4 \times 10^5 \text{ J} \checkmark \text{m} \checkmark \text{e}$ (ii) $mc \Delta T = 1 \times 4200 \times (100-20) = 3.3 \times 10^5 \text{ J} \approx 3 \times 10^5 \text{ J} \checkmark \text{m} \checkmark \text{e}$ | 2 2 | |
| (b) | Photons have higher average energy ✓ ; therefore they are higher frequency ✓ | 2 | Quoting <i>E=hf=kT</i> implies photons. |
| (c) | (i) $E=hf = 6.6 \times 10^{-34} \text{ J s} \times 4.0 \times 10^{14} \text{ Hz}$ = 2.6×10 ⁻¹⁹ J $\approx 3 \times 10^{-19} \text{ J} \sqrt{m} \sqrt{e}$ (ii) Number s ⁻¹ = 1000W/ 3 ×10 ⁻¹⁹ J = 3×10 ²¹ s ⁻¹ $\sqrt{m} \sqrt{e}$ | 2 2 | Can use 2.6×10 ⁻¹⁹ J in (ii) to get 4×10 ²¹ s ⁻¹ Must have 1000 J in 1 s |
| (d) | Transparent case ✓ so many photons escape ✓ / less well absorbed ✓/ bubbles reflect photons ✓ so not penetrating all of water ✓ | 2 | ✓ for any reasonable suggestion including lower power rating, ✓ for explanation ✓ / ✓ ✓ for two separate suggested reasons. |
| (e) | (i) property ✓ explanation ✓ (ii) property ✓ explanation ✓ e.g. insulating ✓ so little heat lost by conduction ✓ /low mass ✓ so little energy needed to heat up ✓ /low thermal conductivity ✓ so cooler outer surface is less dangerous to touch ✓ /unreactive material of case ✓ so does not rust ✓ | 2 2 | Not 'cheap'. Explanation mark must be linked to the property. |

| g |) (a) | (i) = 6.7 = 1.69 (ii) unit o (iii) | $F=GMm/r^{2} \checkmark \Rightarrow g = GM/r^{2}$ $x \ 10^{-11} \times 7.3x \ 10^{22} / (1700 \times 10^{3})^{2}$ $\Rightarrow N \ kg^{-1} \approx 1.7 \ N \ kg^{-1} \checkmark s \checkmark e$ $\Delta V_{g}=gh = 1.7 \times 10 \ 000 = 1.7 \times 10^{4} \ J \ kg^{-1} \checkmark m \checkmark e$ $f \ J \ kg^{-1} \checkmark$ Because g gets weaker as h increases \checkmark | 3 3 1 | g = GM/n Must us | r gets 0 se ∆V _{grav} = gh | | |
|----|--|---|--|-------------|---|--|--|--|
| | (b) | (i) (ii) forces | Arrow radially inwards ✓ Presence of atmosphere ✓; excessive frictional swould stop satellite orbiting/make it spiral in ✓ | 1 2 | Not cra mounta | crashing into Intains or aircraft | | |
| | (c) | (i) <i>f</i> = (ii) (iii) | 5 cm so <i>P</i> = 1/5×10 ⁻² m = 20 D✓ resolution = 8000 m/1024✓ = 7.8 m ✓ moving too fast to take clear photos/variation of object distance too significant ✓ | 1 2 1 | (ii) Area 61m ²) (even if m ² pixe Penalis (iii) Any sugges | | | |
| Au | Quality of Written Communication Apply in Q3 or Q7 where possible. If these have been omitted or are untypical of the paper, look elsewhere. | | | 4 | See QWC criteria (next page) | | | |

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