

Mark Scheme

Physics Specification A

PA02 Mechanics and Molecular Kinetic Theory

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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.

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Dr Michael Cresswell Director General

Instructions to Examiners

- 1 Give due credit to alternative treatments which are correct. Give marks for what is correct; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the script to the Awards meeting if poor presentation forbids a proper assessment. In each paper candidates may be awarded up to two marks for the Quality of Written Communication in cases of required explanation or description. Use the following criteria to award marks:
 - 2 marks: Candidates write legibly with accurate spelling, grammar and punctuation; the answer containing information that bears some relevance to the question and being organised clearly and coherently. The vocabulary should be appropriate to the topic being examined.
 - 1 mark: Candidates write with reasonably accurate spelling, grammar and punctuation; the answer containing some information that bears some relevance to the question and being reasonably well organised. Some of the vocabulary should be appropriate to the topic being examined.
 - 0 marks: Candidates who fail to reach the threshold for the award of one mark.
- 3 An arithmetical error in an answer should be marked AE thus causing the candidate to lose one mark. The candidate's incorrect value should be carried through all subsequent calculations for the question and, if there are no subsequent errors, the candidate can score all remaining marks (indicated by ticks). These subsequent ticks should be marked CE (consequential error).
- 4 With regard to incorrect use of significant figures, normally two, three or four significant figures will be acceptable. Exceptions to this rule occur if the data in the question is given to, for example, five significant figures as in values of wavelength or frequency in questions dealing with the Doppler effect, or in atomic data. In these cases up to two further significant figures will be acceptable. The maximum penalty for an error in significant figures is **one mark per paper**. When the penalty is imposed, indicate the error in the script by SF and, in addition, write SF opposite the mark for that question on the front cover of the paper to obviate imposing the penalty more than once per paper.
- 5 No penalties should be imposed for incorrect or omitted units at intermediate stages in a calculation or which are contained in brackets in the marking scheme. Penalties for unit errors (incorrect or omitted units) are imposed only at the stage when the final answer to a calculation is considered. The maximum penalty is **one mark per question**.
- 6 All other procedures, including the entering of marks, transferring marks to the front cover and referrals of scripts (other than those mentioned above) will be clarified at the standardising meeting of examiners.

Unit 2: PA02

Mechanics and Molecular Kinetic Theory

Question 1

- (a)(i) a collision in which kinetic energy is conserved ✓
- (ii) molecules of a gas are identical
 [or all molecules have the same mass] ✓
 molecules exert no forces on each other except during impact ✓
 motion of molecules is random
 [or molecules move in random directions] ✓
- volume of molecules is negligible (compared to volume of container)
 [or very small compared to volume of container or point particles] ✓
 time of collision is negligible (compared to time between collisions) ✓
 Newton's laws apply ✓
 large number of particles ✓
- (any two) (3)

- (b)(i) the hot gas cools and cooler gas heats up
 until they are at same temperature
 hydrogen molecules transfer energy to oxygen molecules
 until **average k.e.** is the same
- (any two ✓✓)

(ii) (use of $E_k = \frac{3}{2}kT$ gives) $E_k = \frac{3}{2} \times 1.38 \times 10^{-23} \times 420$ ✓
 $= 8.7 \times 10^{-21} \text{ J}$ ✓ (8.69 × 10⁻²¹ J)

(4)
(7)

Question 2

- (a) vector quantities have direction (as well as magnitude)
 and scalar quantities do not ✓
- (1)
- (b) vector: e.g. velocity, acceleration, momentum ✓
 scalar: e.g. mass, temperature, energy ✓
- (2)
- (c)(i) addition of forces (12 + 8) ✓
 (use of $F = ma$ gives) $a = \frac{(12+8)}{6.5} = 3.1 \text{ m s}^{-2}$ ✓ (3.08 m s⁻²)
- (ii) subtraction of forces (12 – 8) ✓
 $a = \frac{(12-8)}{6.5} = 0.62 \text{ m s}^{-2}$ ✓ (0.615 m s⁻²)
- (4)
(7)

Question 3

- (a) resultant force on crate is zero ✓
 forces must have equal magnitudes or size ✓
 (but) act in opposite directions ✓
 correct statement of 1st or 2nd law ✓ max(3)

(b)(i) work done = $F \times d = 640 \times 9.81 \times 8.0$ ✓
 $= 5.0(2) \times 10^4 \text{ J}$ ✓

(ii) (use of $P = \frac{W}{t}$ gives) $P = \frac{5.02 \times 10^4}{4.5} = 1.1(2) \times 10^4 \text{ W}$ ✓
 (allow C.E. for value of work done from (i)) (3)
(6)

Question 4

- (a)(i) car A: travels at constant speed ✓
 (ii) car B: accelerates for first 5 secs (or up to 18 m s^{-1}) ✓
 then travels at constant speed ✓ (3)

(b)(i) car A: distance = 5.0×16 ✓
 $= 80 \text{ m}$ ✓
 (ii) car B: (distance = area under graph)
 distance = $[5.0 \times \frac{1}{2} (18 + 14)]$ ✓
 $= 80 \text{ m}$ ✓ (4)

- (c) car B is initially slower than car A (for first 2.5 s) ✓
 distance apart therefore increases ✓
 cars have same speed at 2.5 s ✓
after 2.5 s, car B travels faster than car A (or separation deceases) ✓ max(3)
(10)

Question 5

- (a)(i) energy = $800 \times 60 = 48 \times 10^3 \text{ J}$ ✓
 (ii) (use of $\Delta Q = mc\Delta\theta$ gives) $48 \times 10^3 = 60 \times 3900 \times \Delta\theta$ ✓
 $\Delta\theta = 0.21 \text{ K}$ ✓ (0.205 K)
 (allow C.E. for value of energy from (i)) (3)
- (b) $\Delta Q = ml$ gives 500×60 ✓ $= m \times 2.3 \times 10^6$ ✓
 $m = 0.013 \text{ kg}$ ✓ (3)

- (c) not generating as much heat internally ✓
 still losing heat (at the same rate)
 [or still sweating] ✓
 hence temperature will drop ✓ max(2)
(8)

Question 6

(a) (moment) force \times perpendicular ✓ distance (from the point) ✓ (2)

(b)(i) the point in a body where the resultant torque is zero
 [or where the (resultant) force of gravity acts or where the weight acts through] ✓

(ii) $F \times 2.5 = 1800 \times 0.35$ ✓
 $F = 250\text{ N}$ ✓ (252 N)

(iii) $F_R = (1800 - 252)$ ✓
 $= 1500\text{ N}$ ✓ (1548) N
 [use of $F = 250\text{ N}$ gives $F_R = 1550\text{ N}$ or 1600 N]
 (allow C.E. for incorrect value of F from (ii)) (5)

(c) force must have a horizontal component ✓
 F (therefore) increases in magnitude ✓
 and act at an angle (to the vertical) towards the car ✓ (3)
(10)

Quality of Written Communication marks: Q3 (a) and Q6 (c) ✓✓ (2)
(2)