Mark scheme January 2003

GCE

Physics A

Unit PA02

Unit 2: Mechanics and Molecular Kinetic Theory

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.

1

(a)(i) resultant force acting on tray is zero [or $P + W = Q$] ✓
resultant torque is zero
[or correct moments equation
or anticlockwise moments = clockwise moments] ✓

(a)(ii) $W = 0.12 \times 9.81 = 1.2$ N ✓ (1.18 N)

(a)(iii) (taking moments about P gives)
$Q \times 0.1 = 0.12 \times 9.81 \times 0.25$ ✓
$Q = 2.9$ N (2.94 N) ✓
$P = 2.9 - 1.2 = 1.7$ N ✓ (or $2.94 - 1.18 = 1.76$ N)
(allow C.E. for values of W and Q) (*6*)

(b) placed at Q ✓
no additional turning moment about Q ✓ (*2*)
(*8*)

2

(a) kinetic energy changes to potential energy ✓
potential energy calculated by measuring h ✓
equate kinetic energy to potential energy to find speed ✓
[or use h to find s ✓
use $g \sin\theta$ for a ✓
use $v^2 = u^2 + 2as$ ✓]
[or use h to find s ✓
time to travel s and calculate v_{av} ✓
$v = 2v_{av}$ ✓] (*3*)

(b)(i) $p\ (= mv) = 0.5(0) \times 0.4(0) = 0.2(0)$ ✓ N s (or kg m s^{-1}) ✓

(b)(ii) (use of $m_p v_p = m_t v_t$ gives) $0.002(0)\ v = 0.2(0)$ ✓
$v = 100$ m s^{-1} ✓ (*4*)

(c)(i) kinetic energy is not conserved ✓

(c)(ii) initial kinetic energy = $\frac{1}{2} \times 0.002 \times 100^2 = 10$ (J) ✓
final kinetic energy = $\frac{1}{2} \times 0.5 \times 0.4^2 = 0.040$ (J) ✓
hence change in kinetic energy ✓
(allow C.E. for value of v from (b)) (*4*)
(*11*)

3(a) displacement is a vector ✓
ball travels in opposite directions ✓ $_{max}$(*1*)

(b) velocity is rate of change of displacement
average speed is rate of change of distance
velocity is a vector [or speed is a scalar]
velocity changes direction any two ✓ ✓ (*2*)

(c)(i) $a = \dfrac{(-6.0 - 8.0)}{0.10}$ ✓
$= (-)140.\text{m s}^{-1}$ ✓ (allow C.E. for incorrect values of Δv)

(c)(ii) $F = 0.45 \times (-)140 = (-)63$ N ✓ (allow C.E for value of a)

(c)(iii) away from wall ✓
at right angles to wall ✓
[or back to girl ✓ ✓]
[or opposite to direction of velocity at impact ✓ ✓] <u>(*5*)</u>
<u>(*8*)</u>

4(a)(i) $pV = nRT$ ✓
$V = \dfrac{15 \times 8.31 \times 290}{500 \times 10^3}$ ✓ (gives $V = 7.2 \times 10^{-2}$ m^3)

(a)(ii) (use of $E_k = \frac{3}{2}kT$ gives) $E_k = \frac{3}{2} \times 1.38 \times 10^{-23} \times 290$ ✓
$= 6.0 \times 10^{-21}$ J ✓ (*4*)

(b) (use of $pV = nRT$ gives) $n = \dfrac{420 \times 10^3 \times 7.2 \times 10^{-2}}{8.31 \times 290}$ ✓
[or use $p \propto n$]
$n = 13$ moles ✓ (12.5 moles) (*2*)

(c) pressure is due to molecular bombardment [or moving molecules] ✓
when gas is removed there are fewer molecules in the cylinder
[or density decreases] ✓
(rate of) bombardment decreases ✓
molecules exert forces on wall ✓
$\overline{c^2}$ is constant ✓

[or $pV = \frac{1}{3}Nm\langle c^2 \rangle$ ✓
V and m constant ✓
$\langle c^2 \rangle$ constant since T constant ✓
$p \propto N$ ✓]

[or $p = \frac{1}{3}\rho\langle c^2 \rangle$ ✓
explanation of ρ decreasing ✓
$\langle c^2 \rangle$ constant since T constant ✓
$p \propto \rho$ ✓] $_{max}$<u>(*4*)</u>
<u>(*10*)</u>

5

(a) (use of $mc\Delta\theta = Pt$ gives)
$0.725 \times c \times (100 - 20)$ ✓ $= 2000 \times 120$ ✓
$c = 4100$ ✓ J kg^{-1} ✓ (4140 J kg^{-1}) (*4*)

(b)(i) (use of $mL = Pt$ gives) $94 \times 10^{-3} L = 2000 \times 105$ ✓
$L = 2.2 \times 10^{6} \text{ J kg}^{-1}$ ✓

(b)(ii) no evaporation (before water heated to boiling point)
no heat lost (to the surroundings)
heater 100% efficient any two ✓ ✓ (*4*)
(*8*)

6(a)(i) 70 m s^{-1} ✓

(a)(ii) $v = 9.81 \times 2.0$ ✓
$= 20 \text{ m s}^{-1}$ ✓ (19.6 m s^{-1})

(a)(iii) $v = \sqrt{(70^2 + 19.62^2)} = 73 \text{ m s}^{-1}$ ✓
direction: $\tan\theta = \dfrac{19.6}{70} = 0.28$
$\theta = 15.6^{\circ}$ ✓ ($\pm 0.1^{\circ}$) (to horizontal) ✓
(allow C.E. for values of v from (i) and (ii))
[or use of correct scale drawing] (*5*)

(b)(i) air resistance is greater than weight ✓
(hence) resultant force is upwards ✓
hence deceleration (Newton's second law) ✓

(b)(ii) air resistance decreases as speed decreases ✓
weight equals air resistance (hence constant speed)
(hence) resultant force is zero (Newton's first law) ✓ max(*4*)
(*9*)

7(a) mark out (equal) distances along height being raised ✓
measure time taken to travel each of these distances ✓
times should be equal ✓
[or use a position sensor attached to a data logger
measure distance or speeds at regular intervals
increase in distance or speeds should be constant] max(*2*)

(b) find work done by motor from gain in potential energy of metal block ✓
divide work done by time to find power ✓
measurements: mass of block, height block has risen and time taken ✓
[or power = Fv
force is weight of block
velocity is velocity of block
same measurements as above] max(*2*)
(*4*)

The Quality of Written Communication marks are to be awarded for the quality of answers to Q5(a) and Q6(b) ✓ ✓ (*2*)
(*2*)