AQA

# A-LEVEL

# Physics

PHA5/2C – Applied Physics
Mark scheme

2450
June 2015

Version 1: Final mark scheme

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| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 1 a i | $\alpha = T/I$ =8.80 /0.565 (= 15.6 rad $s^{-2}$) ✓<br>use of $t = (\omega_2 - \omega_1)/\alpha$<br>leading to $t$ = 8.08 s ✓ | | 2 | |
| 1 a ii | $\theta$ = ½ (172 + 195) × 126 ✓<br>= 23100 rad ✓<br>23100/2π = 3680 rev ✓<br>OR<br>rev per s = 1200/60 (=20) ✓<br>$\theta$ = ½ (172 + 195) × 20 ✓<br>= 3670 rev ✓ | Accept alternative ways of calculating area under graph<br>Areas are: 504 rad or 80 rev<br>21670 rad or 3450 rev<br>945 rad or 150 rev<br>Numbers will vary if 8.1 s used for acceleration period<br>Last mark: give CE for wrong $\theta$ | 3 | |
| 1 b i | Shows curve of increasing gradient up to first vertical dotted line ✓<br>OR Shows curve of decreasing gradient up to first vertical dotted line ✓ | MARK bii BEFORE bi<br>Answer must match the answer given in part b ii<br>i.e. α increasing: decreasing gradient<br>α decreasing: increasing gradient<br><br>Mark awarded for shape only; ignore any changes to the height of the graph or where curve reaches 126 rad $s^{-1}$ | 1 | |
| 1 b ii | Mass of washing will decrease as it loses water, so M of I will decrease. ✓<br>($T$ constant) so $\alpha$ increases. ✓<br>OR washing moves closer to drum, increasing M of I ✓<br>($T$ constant) so $\alpha$ decreases. ✓<br>OR friction (torque) increases with speed ✓<br>so $\alpha$ decreases ✓ | Do not credit answers in terms of conservation of angular momentum. | 2 | |
| **Total** | | | 8 | |

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|---|---|---|---|---|
| 2 a | Law of conservation of angular momentum applies and $I_1\ \omega_1 = I_2\omega_2$<br>OR Law of conservation of angular momentum applies and angular momentum = $I\ \omega$ ✓<br>(because no external torque acts)<br><br>Adding plasticine increases $I$ ✓<br><br>So $\omega$ must decrease to maintain $I\ \omega$ constant / to conserve angular momentum ✓ | | 3 | |
| 2 b | $I \times 3.46 = (I + 0.016 \times 0.125^2) \times 3.31$ ✓<br>$I = 0.00552$ kg m$^2$ ✓ 3 sf ✓ | Useful: $mr^2 = 2.5 \times 10^{-4}$<br><br>Sig fig mark s an independent mark<br><br>If method correct but incorrect conversion of g to kg or mm to m, award 1 mark out of first 2 marks. | 3 | |
| 2 c i | $\Delta E = ½I\omega_1^2 - ½(I + mr^2)\omega_2^2$<br>$= [½ \times 5.52 \times 10^{-3} \times 3.46^2] - [½ \times 5.77 \times 10^{-3} \times 3.31^2]$ ✓<br>$= 1.39 \times 10^{-3}$ J ✓ | CE for $I$ of turntable or $I$ of plasticine from 2b<br><br>Answers will vary depending on rounding eg accept $1.43 \times 10^{-3}$ | 2 | |
| 2 c ii | Work done against friction/deforming plasticine as it collides with turntable/to move or acclerate plasticine ✓ | Allow heat loss on collision<br><br>Do not allow energy to sound. | 1 | |
| **Total** | | | 8 | |

| Question | Answers | Additional Comments/Guidance | Mark | ID details |
|---|---|---|---|---|
| 3a | **E** to **X** circled | | 1 | |
| 3 b i | $p_1V_1/T_1 = p_2V_2/T_2$<br>$T_2 = p_2V_2T_1 / p_1V_1$ ✓<br>$= \frac{4.6 \times 10^5 \times 1.5 \times 10^{-4} \times 310}{1.0 \times 10^5 \times 5.0 \times 10^{-4}}$<br>=430 K ✓ | Also: work out $n$ or $nR$ in $p_1V_1 = nRT_1$<br>Substitute in $p_2V_2 = nRT_2$<br>Accept use of $4.5 \times 10^5$ Pa for $p_2$<br>Giving $T_2 =$ 420 K<br>$nR = 0.161$<br>$n = 1.94 \times 10^{-2}$ | 2 | |
| 3 b ii | Work per cycle = area enclosed by loop ✓<br>Suitable method for calculating area used correctly e.g. counting squares ✓<br>Correct scaling factor used leading to 70J ± 5 J ✓ | e.g. 355 small sq × 0.2 ×$10^5$ × 0.1×$10^{-4}$<br>OR<br>14×1 cm squares × 1.0×$10^5$ × 0.5×$10^{-4}$<br>If no. of squares incorrectly counted but correct scaling factor used for their squares give CE for final answer | 3 | |
| 3 b iii | P = 70 × 420/60 = 500 W ✓ | CE from 3 b ii | 1 | |
| 3 b iv | | | 6 | |

Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 4 and apply a 'best-fit' approach to the marking.

| 0 marks | Level 1 (1–2 marks) | Level 2 (3–4 marks) | Level 3 (5–6 marks) |
|---|---|---|---|
| The information conveyed by the answer is sketchy, and neither relevant or coherent.<br>*The candidate shows inadequate understanding of the operation of the compressor and how its performance will change.* | The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary.<br>*The candidate has some appreciation of how the performance will change, but is only likely to cover* ***up to three*** *of the points listed below, and probably without reasons.* | The information conveyed in the answer may be less well organized and not fully coherent. There is less use of specialist vocabulary or specialist vocabulary may be used or spelled incorrectly. The form and style of writing is less appropriate.<br>*The candidate is able to make some correct predictions concerning how the diagram, work done, power and temperature (but not all) will change, but reasoning* | The information conveyed by the answer is clearly organized, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question.<br>*A good attempt is made at how the compressor will operate at higher pressures. Statements are made relating to the diagram, work or power, temperature and* |

| | | | |
|---|---|---|---|
| | | *will be less confident. Answers will include 4 to 6 of the points listed below.* | *flywheel, backed up by some sound reasoning.* Answers at this level will include more than 6 of the points listed below. |

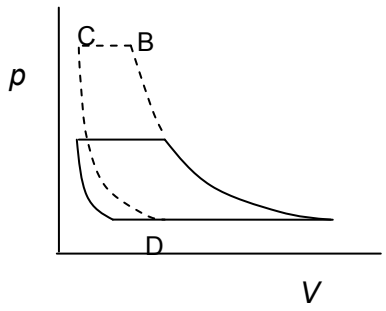
**examples of the points made in the response**

1. area of loop increases as *p* increases
2. BC at higher pressure/point B moves up and to left
3. *p* higher in $W = p\Delta V$ for BC / higher *p* more work to force air into tank
4. (so) work done per cycle increases
5. input power increases (if speed constant)
6. temperature will increase
7. reason: because B gets further from graph origin / $p_2V_2$ gets larger / int energy increases because little time for heat transfer
8. higher *p* means more applied crankshaft torque (between dead centres)
9. so jerkier motion
10. flywheel needed to smooth motion of crankshaft
11. flywheel acts as energy store
12. speeding up/gaining energy - then slowing down/losing energy when torque needed is high / takes piston over dead centres
13. application of $T = I\alpha$: fluctuations in $\omega$ small if $I$ large.
14. expansion of air in clearance volume will have negative effect on area
15. vol of air drawn in per cycle will decrease
16. increase in work per cycle gets progressively smaller as *p* increases

**extra information**

**check to see if Fig 6 drawn on**

bullet points 1, 14 and 15 can be supported by diagram
Expect to see: BC to be at higher pressure and loop to get narrower
Candidates are unlikely to show the effect of clearance volume (CD)




Point 6: accept correct use of *pV/T* constant

14,15,16 unlikely but give credit in lieu of other points

| | | | |
|---|---|---|---|
| **Total** | | | 13 |

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|---|---|---|---|---|
| 4 a | $T_H$ = 273 + 540 = 813 K<br>$T_C$ = 273 + 25 = 298 K ✓<br>$\eta_{max}$ = (813 – 298)/813 = 0.633 or 63.3 % ✓ | Both temperatures correct for 1st mark.<br>No CE for incorrect temperatures.<br>If °C used $\eta_{max}$ = 95.4% | 2 | |
| 4 b | input power = $\frac{\text{output power}}{\eta_{max}}$<br>= 48.0 / 0.633 = 75.8 MW ✓ | Give CE from 4a unless $\eta_{max} > 1$<br>If $\eta_{max}$ = 0.95 used, input power = 50 MW | 1 | |
| 4 c | • heat exchanger will not convert all (internal) energy of salts to (internal) energy of water / steam<br>• (unwanted) heat transfer losses **from** ……. **to** ……..<br>• friction … in bearings of all machinery/ in bearings of turbine generator / between moving parts / between moving surfaces /from viscosity of lubricants<br>• power needed to drive auxiliary equipment e.g. pumps, motors<br>• turbine cycle will not give max theoretical efficiency<br>any 2 ✓✓ | WTTE<br>e.g. turbine to surrounding air<br>do not accept bland statements e.g. 'heat loss to surroundings', 'friction' /'friction in steam turbine'<br>Do not allow: turbine generator is not 100% efficient | 2 | |
| **Total** | | | 5 | |