

AQA A-LEVEL PHYSICS

PHYSICS



EXAM QUESTION PACK

UNIT 5C APPLIED PHYSICS OLD SPECIFICATION PAPERS

STEMUP

These questions belong to AQA, not to us.

The examination questions, mark schemes and examiner reports in this pack were written and published by AQA. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with AQA and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. AQA has not endorsed, approved or been involved in the production of it. AQA and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

AQA publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at aqa.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Please write clearly in block capitals.

Centre number

--	--	--	--	--

Candidate number

--	--	--	--

Surname

Forename(s)

Candidate signature

A-level PHYSICS A

Unit 5C Applied Physics
Section B

Tuesday 28 June 2016

Morning

Time allowed: The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:

- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

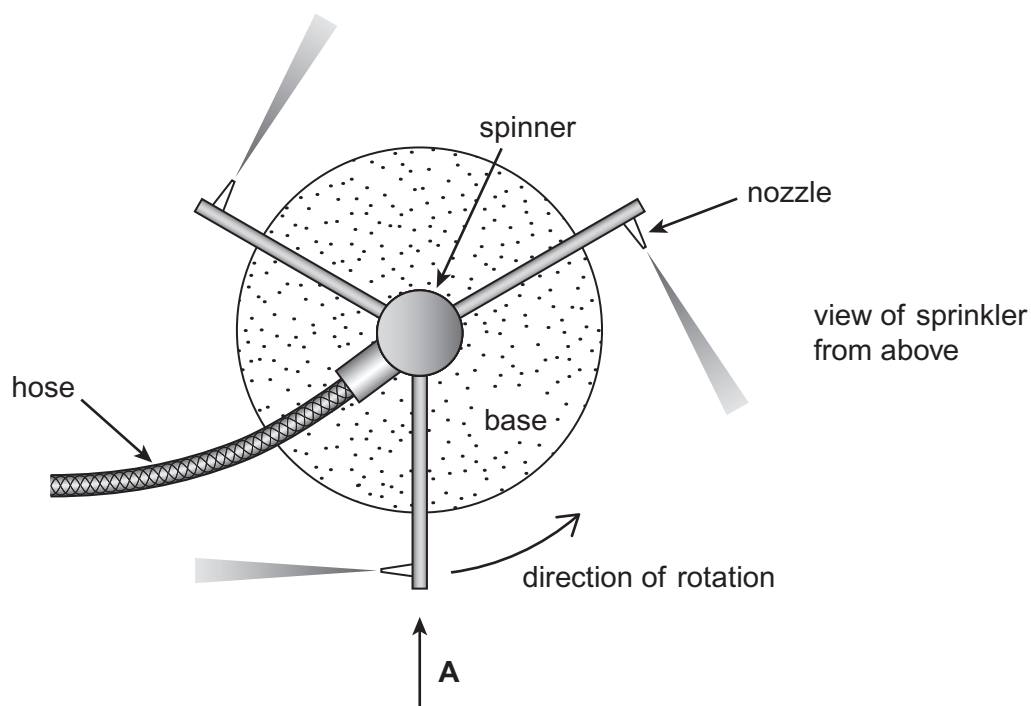


Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1 A garden sprinkler consists of a fixed base and a rotating spinner having three arms as shown in **Figure 1**.

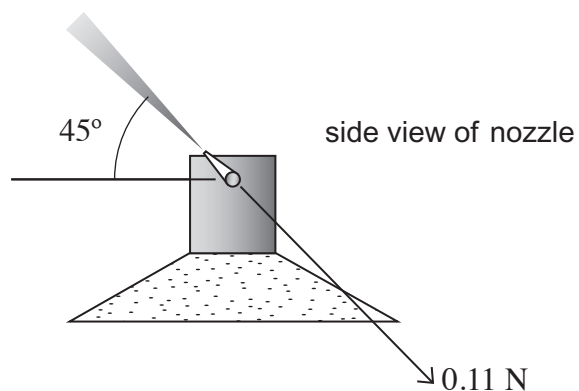
Figure 1



At the end of each arm is a nozzle at 90° to the arm and inclined at 45° to the horizontal. Water flows in jets at a constant rate from these nozzles when the hose water tap is turned on.

Figure 2 shows a side view of one of the nozzles viewed in the direction of arrow **A** in **Figure 1**.

Figure 2



The water jets produce reaction forces that act on the arms which cause the spinner to rotate. The base remains fixed in position. In operation, the spinner rotates at a constant rate of 240 rev min^{-1} . The nozzles rotate in a horizontal circle of radius 120 mm.

- 1 (a)** Each water jet exerts a constant force of 0.11 N on its arm at 45° to the horizontal.

Show that the torque exerted on the spinner by the jets of water is about $3 \times 10^{-2} \text{ N m}$.

[2 marks]

- 1 (b) (i)** Explain why, when the water tap is turned on, the spinner accelerates initially but then reaches a constant angular speed.

Assume that, when the tap is turned on, the flow-rate of the water from the jets is constant.

[2 marks]

- 1 (b) (ii)** Calculate the power dissipated by the frictional torque acting between the spinner and the fixed base when the sprinkler is rotating at 240 rev min^{-1} .

[2 marks]

power = _____ W

Turn over ►



- 1 (c)** When the water is suddenly turned off all the kinetic energy of the spinner and arms is dissipated as heat due to work done by the frictional torque and the spinner makes a further 13 rotations before coming to rest. Assume uniform deceleration.

- 1 (c) (i)** Calculate the time taken for the spinner to come to rest.

[2 marks]

time = _____ s

- 1 (c) (ii)** Show that the kinetic energy of the spinner when rotating at its operating speed is about 2 J.

[1 mark]

- 1 (c) (iii)** Determine the moment of inertia of the spinner about its axis of rotation.

[1 mark]

moment of inertia = _____ kg m²



Turn over for the next question

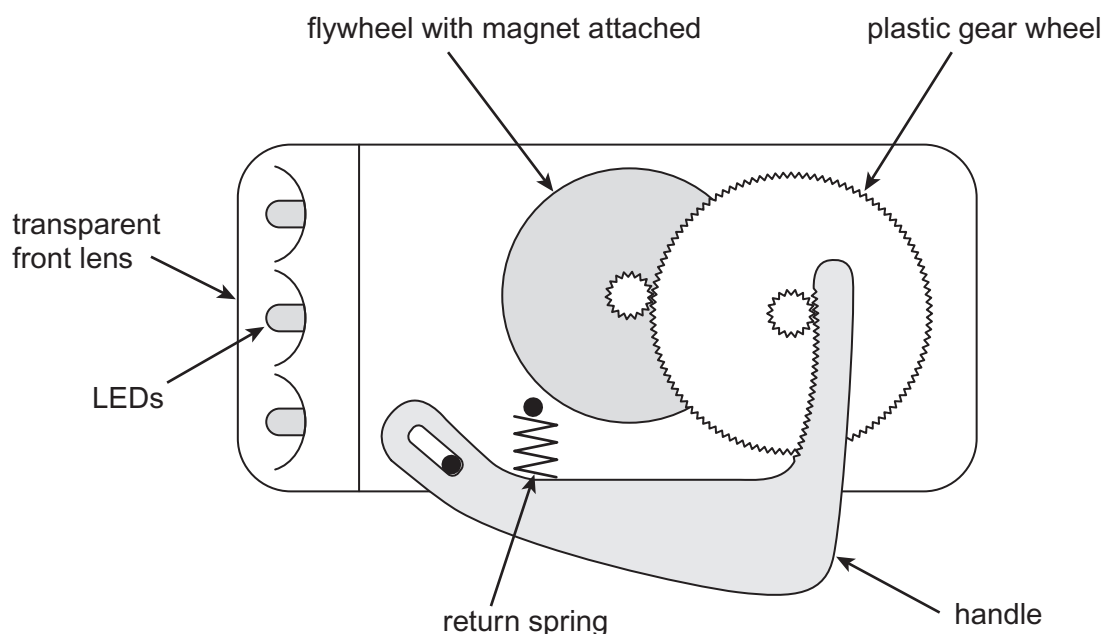
**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



- 2 **Figure 3** shows the mechanism of a dynamo torch for providing light without the use of batteries. When the handle is squeezed the gears rotate the flywheel increasing the kinetic energy stored in the flywheel. On the same axle as the flywheel is a magnet which generates an emf in surrounding coils as it rotates. The magnet, coils and electrical connections are not shown.

Figure 3



When the handle is released the mechanism disengages and a spring returns the handle to its original position. During this time the gears continue to turn. The energy of the flywheel enables it to continue to rotate for several seconds.

A designer wishes to enable the flywheel to store more energy and thus rotate for longer after the handle has been released.

The radius of the flywheel is limited by the overall size of the torch and cannot be increased.

Describe and explain other changes that can be made to the mechanism and flywheel to store more energy. Your answer should include consideration of:

- the flywheel's shape
- the material from which it is made
- changes to the mechanism.

The quality of your written communication will be assessed in your answer.

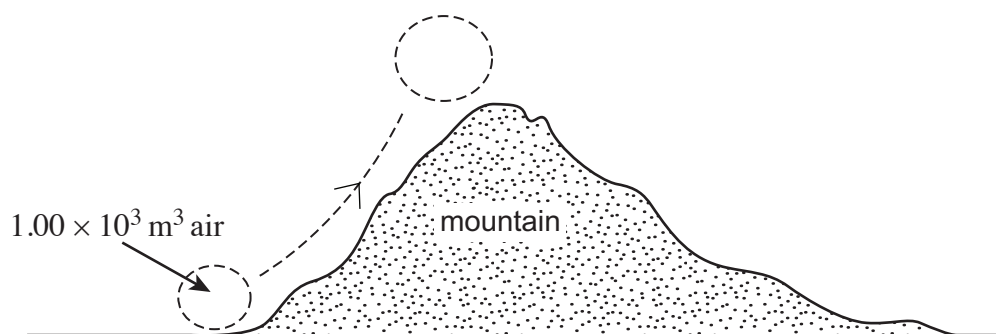
[6 marks]

[illegible]

- 3** This question is about a group of a fixed number of air molecules that remain together called an air pocket.

Figure 4 shows an air pocket of volume $1.00 \times 10^3 \text{ m}^3$ near the base of a mountain where the temperature is 25°C and atmospheric pressure is $1.01 \times 10^5 \text{ Pa}$. The air pocket expands adiabatically as it rises to the top of the mountain where the air pressure is lower.

Figure 4



- 3 (a)** Calculate the new volume of the air pocket when it reaches the top of the mountain, where the pressure is $8.25 \times 10^4 \text{ Pa}$.
Give your answer to an appropriate number of significant figures.

[3 marks]

adiabatic index γ for air = 1.40

volume = _____ m^3



- 3 (b)** Meteorologists use the term adiabatic lapse rate for the temperature change per km when air rises as it expands adiabatically.

Calculate the temperature of the air pocket when it has reached the top of the mountain, and hence estimate the height of the mountain assuming the adiabatic lapse rate is 9.8 K km^{-1} .

[3 marks]

temperature = _____ °C

height = _____ km

- 3 (c)** Work is done by the air pocket as it expands against the surrounding air. Explain, with reference to the first law of thermodynamics, why the temperature of the air decreases as the air pocket rises.

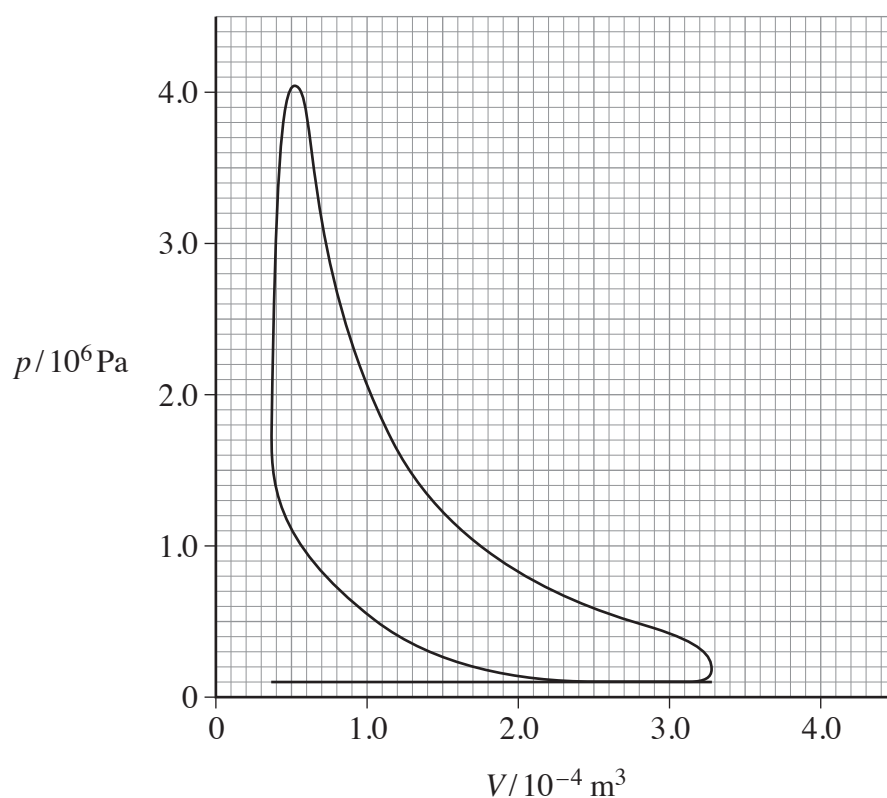
[3 marks]



- 4 (a) Explain the **basic** differences in operation between a petrol engine and a diesel engine. **[2 marks]**

- 4 (b) **Figure 5** shows the indicator diagram taken during a test from one cylinder of a four cylinder four-stroke petrol engine.

Figure 5



Data from the test are as follows:

engine speed:	$2000 \text{ rev min}^{-1}$
calorific value of fuel:	44.0 MJ kg^{-1}
fuel consumption:	$1.1 \times 10^{-3} \text{ kg s}^{-1}$



4 (b) (i) Draw an **X** on **Figure 5** to show where in the cycle the spark would occur.

[1 mark]

4 (b) (ii) Calculate the indicated power of the engine.

[4 marks]

power = _____ W

4 (b) (iii) Calculate the thermal efficiency of the engine.

[2 marks]

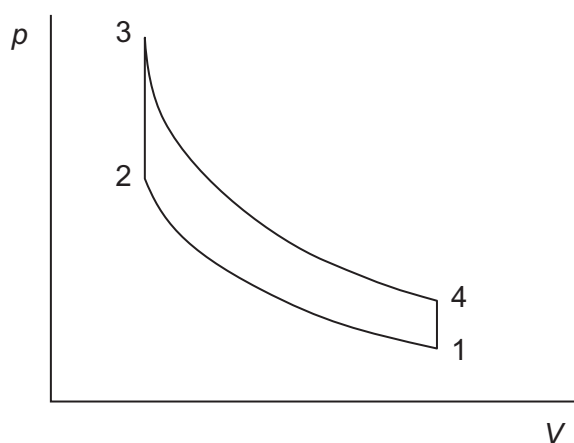
thermal efficiency = _____

Turn over ►



4 (c) **Figure 6** shows the $p - V$ diagram for a theoretical or ideal petrol engine (Otto) cycle.

Figure 6



Which **one** of the following lines in the table best represents what is occurring in different parts of the ideal cycle of **Figure 6**?

Place a tick (✓) in the right-hand column to show the correct answer.

[1 mark]

1 → 2	2 → 3	3 → 4	4 → 1	✓ if correct
induction	compression	expansion	exhaust	
compression	heating	expansion	cooling	
induction	heating	cooling	exhaust	
cooling	compression	heating	expansion	

END OF QUESTIONS

10

Copyright Information

For confidentiality purposes, from the November 2015 examination series, acknowledgements of third party copyright material will be published in a separate booklet rather than including them on the examination paper or support materials. This booklet is published after each examination series and is available for free download from www.aqa.org.uk after the live examination series.

Permission to reproduce all copyright material has been applied for. In some cases, efforts to contact copyright-holders may have been unsuccessful and AQA will be happy to rectify any omissions of acknowledgements. If you have any queries please contact the Copyright Team, AQA, Stag Hill House, Guildford, GU2 7XJ.

Copyright © 2016 AQA and its licensors. All rights reserved.



A-level Physics

PHYA5/2C – Applied Physics
Mark scheme

2450
June 2016

Version: 1.0 Final

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

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

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

Question	Answers	Additional Comments/Guidance	Mark	ID details
1(a)	$F = 0.11 \times \cos 45 (= 0.078 \text{ N}) \quad \checkmark$ $T = F \times 0.12$ on each arm $= 9.4 \times 10^{-3} \text{ N m}$ Total $T = 3 \times 9.4 \times 10^{-3} = 0.028 \text{ N m} \quad \checkmark$	Do not allow $\sin 45$ instead of $\cos 45$ but give CE for 2 nd mark. No CE for 2nd mark if no attempt to resolve force i.e. no $\cos$ or $\sin$.	2	
1(b)(i)	Initially friction torque < applied torque so spinner accelerates / frictional torque increases with speed $\checkmark$ Eventually applied torque = friction/resistive torque and spinner angular speed remains constant $\checkmark$	For a full answer is in terms of 'force' rather than 'torque' give max 1 mark.	2	
1(b)(ii)	$240 \text{ rev min}^{-1} = 25 \text{ rad s}^{-1}$ OR use of $P = T\omega$ with attempt to convert rev min^{-1} to $\text{rad s}^{-1} \quad \checkmark$ $P = T\omega$ $P = 0.028 \times 25 = 0.70 \text{ W} \quad \checkmark$	Accept attempt such as multiplying by π or dividing by π or 2π , or dividing 240 by 60 and not using 2π . No CE for incorrect ω T must be either 0.028 or 0.03 Nm 0.75 W if 3×10^{-2} used	2	
1(c)(i)	Use of $\theta = \frac{1}{2}(\omega_1 + \omega_2) t$ OR $\theta = 13 \times 2\pi \quad \checkmark$ $= 0.5 \times 25 \times t$ $t = 6.5 \text{ s} \quad \checkmark$	CE for ω_1 from b ii	2	
1(c)(ii)	$E_K = \text{mean power} \times \text{time}$ $= 0.35 \times 6.5 = 2.3 \text{ J}$ OR $E_K = T\theta = 0.028 \times 26\pi = 2.3 \text{ J} \quad \checkmark$	CE for values of θ and t from c i and P from b ii Allow use of $E_K = \frac{1}{2} I\omega^2$ with I from part c iii If $T = 0.03 \text{ N m}$ used, $E_K = 2.4(5) \text{ J}$	1	
1(c)(iii)	$E_K = \frac{1}{2} I\omega^2$ $I = 2 E_K / \omega^2 = 7.3 \times 10^{-3} \text{ kg m}^2 \quad \checkmark$	If 2 J used for E_K , $I = 6.3 \times 10^{-3} \text{ kg m}^2$ Alternative: use of $I = T / \alpha$ Where $\alpha = 25 / \text{ans c i}$ When $T = 3 \times 10^{-2}$, $I = 7.76 \times 10^{-3} \text{ kg m}^2$ CE for ω	1	

Total				10
question	answers	extra information	mark	
2			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. <i>The candidate shows inadequate understanding of the concept of moment of inertia. Formulae may be quoted from the Formulae booklet, but the candidate is unable to apply their meaning to the question.</i>	The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. <i>The candidate shows little understanding of the factors which affect energy storage in a flywheel. They may relate rotational E_K to angular speed and/or M of I, but not confidently cover aspects of mass, and distribution of mass around the axis, and may not relate their answers well to the context of the question.</i>	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. <i>The candidate may not tackle all of the bullet points in the question fully, but should have a fairly good idea of the factors that affect energy storage. Candidates are likely to relate E_K to angular speed² and to the way the mass is distributed around the axis.</i>	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. <i>All three bullet points will be addressed. Answers will relate E_K to the factors that give high M of I, and means by which the angular speed can be increased, with sensible suggestions concerning the mechanism and/or reducing friction.</i>	
examples of the points made in the response E_K proportional to ω^2 E_K proportional to I <u>Shape</u> I depends on mass and distribution of mass around axis. $I = \Sigma mr^2$ so arrange more m at outer edge of flywheel		extra information Also allow - use material of higher tensile strength - for higher speeds without bursting/to withstand rotational stresses - use magnet of greater mass - answers in terms of lowering electromagnetic drag		

• By using heavy rim and spokes/thin centre web • Increase thickness (to increase m or I) <u>Material</u> • Higher density material • Gives greater mass for given size <u>Mechanism</u> Increase ω by: • changing gear ratio/reduce size of small gears/give higher ω per push • Longer rack segment or more teeth on rack • Reduce friction at bearings or between gears • use lubrication or roller bearings • small increase in ω gives large increase in E_K (because ω^2)	• sketches which convey correct info clearly • use of 'depends on' for 'proportional to' <i>Level 3: 1st 2 points plus 6 other points from shape, material and mechanism</i> <i>Level 2: between 4 and 7 points</i> <i>Level 1 fewer than 4 points.</i> <i>Quoting formulae alone is not enough.</i> <i>Ignore references to strength of spring.</i>
---	--

Question	Answers	Additional Comments/Guidance	Mark	ID details
3(a)	$1.01 \times 10^5 \times (1.0 \times 10^3)^{1.4} = 8.25 \times 10^4 \times V_2^{1.4} \checkmark$ Leading to $V_2 = 1.16 \times 10^3 \text{ m}^3$ or $1160 \text{ m}^3 \checkmark$ 3 s f $\checkmark$	1st mark: or for rearranging the equation first and correct numbers seen. The sig fig mark is an independent mark but some working must be shown.	3	
3(b)	$(25^\circ\text{C} = 298 \text{ K})$ $p_1 V_1 / T_1 = p_2 V_2 / T_2$ with correct p, V, T substituted OR $T_2 = p_2 T_1 / p_1 V_1$ with correct p, V, T substituted $\checkmark$ $T_2 = (282 \text{ K}) = 9.0^\circ\text{C} \checkmark$ $298 - 282$ or $25 - 9 = 16 \text{ K}$ $16/9.8 = 1.6(3) \text{ km} \checkmark$	Accept use of $p_1 V_1 = k T_1$ and $T_2 = p_2 V_2 / k$ Answer line requires T_2 in $^\circ\text{C}$ but accept in K if student has changed the unit on answer line to K. Allow CE for third mark using student's T_2 but must use temperature change .	3	
3(c)	$Q = \Delta U + W$ (in adiabatic expansion) $Q = 0 \checkmark$ W is +ve so $W = -\Delta U$ meaning internal energy decreases OR work is done at expense of internal energy [WTTE] $\checkmark$ (internal energy related to T) therefore T falls. $\checkmark$	For 1st mark do not allow Q is constant/no change Ignore Δ if used with Q or W Do not accept 'thermal' energy for internal energy.	3	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4(a)	Diesel: air only is drawn into cylinder Petrol: air and fuel is drawn into cylinder both points ✓ Diesel: ignition is by temperature rise during compression/compression ignition Petrol: ignition by means of spark (plug) both points ✓	Accept: heating at constant volume in (ideal) petrol engine and constant pressure in (ideal) diesel engine ✓ Do not allow: petrol engine has spark plug, diesel doesn't WTTE	2	
4(b)(i)	X marked on curved compression line between $p = 0.7 \times 10^6$ Pa and 1.7×10^6 Pa ✓		1	
4(b)(ii)	Indicated work = area of loop ✓ Appropriate method for finding area e.g. counting squares ✓ Correct scaling fact or used to give work per cycle of between 250 and 325 (J) ✓ (Calculates no cycles per s ($\frac{1}{2} \times 2000/60$) = 16.7) $P = 4 \times 16.7 \times 287 = 19.2$ kW ✓	Either stated explicitly or shown on Fig 5 e.g. by shading or ticking squares or subsequent correct working. 287 small squares is a good estimate. Scaling factor is 1 J per small square Allow 10 to 13 1 cm squares Scaling factor is 25 J per 1 cm square CE for 4th mark using incorrect work per cycle	4	
4(b)(iii)	Input power = CV $\times$ fuel flow rate $= 44 \times 10^6 \times (1.1 \times 10^{-3})$ (= 48.4 kW) ✓ $\eta_{\text{thermal}} = 19.2/48.4 = 0.40$ ✓	CE from 4 b ii unless $\eta_{\text{thermal}} > 1$	2	
4(c)	Tick against second answer line ✓		1	
Total			10	

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2015

Physics A

PHYA5/2C

**Unit 5C Applied Physics
Section B**

Thursday 18 June 2015 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 5 P H Y A 5 2 C 0 1

WMP/Jun15/PHYA5/2C/E5

STEMUP.CO.UK

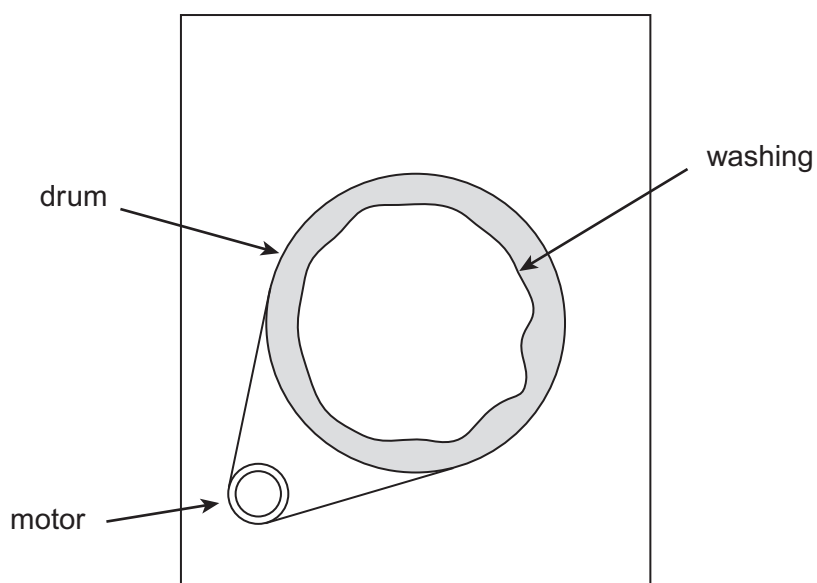
PHYA5/2C

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

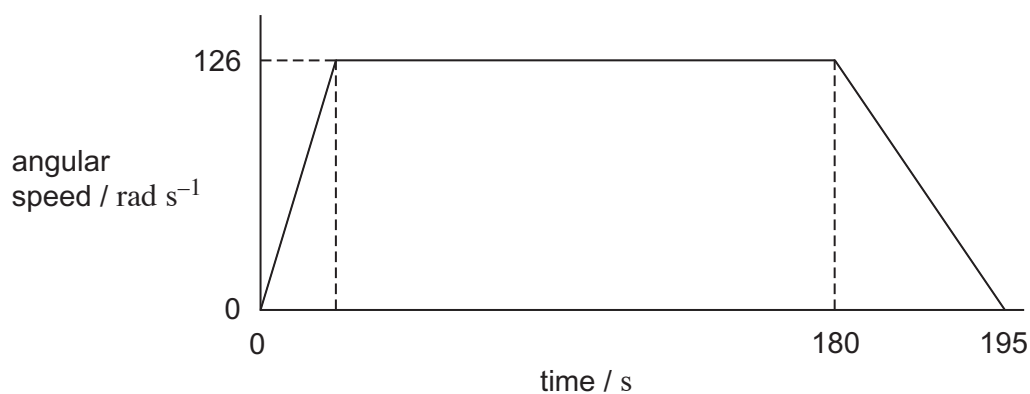
- 1** During the spin part of a washing machine programme the maximum rotational speed is 126 rad s^{-1} ($1200 \text{ rev min}^{-1}$). The moment of inertia of the drum and washing at the start of the spin part of the cycle is 0.565 kg m^2 . Assume that the wet washing is evenly distributed around the drum as shown in **Figure 1**.

Figure 1



- 1 (a)** **Figure 2** shows the variation of angular speed with time for the spin part of the cycle. The graph is not drawn to scale.

Figure 2



The motor provides a torque of 8.80 N m to accelerate the drum to 126 rad s^{-1} . The drum rotates at 126 rad s^{-1} until near the end of the spin cycle, when the drum decelerates uniformly to zero angular speed in 15 seconds. Friction at the bearings may be neglected. Assume that during acceleration the moment of inertia of the drum and washing remains constant.

- 1 (a) (i) Show that the drum accelerates for about 8 s.

[2 marks]

- 1 (a) (ii) Calculate the total number of revolutions made by the drum during the 195 s shown in Figure 2.

[3 marks]

number of revolutions = ...

- 1 (b) (i) In practice, at the start of the cycle the acceleration will not remain constant. Draw on Figure 2 a line to show how the initial part of the graph will change.

[1 mark]

- 1 (b) (ii) Explain your reasons for the line you have drawn.

[2 marks]

.....

.....

.....

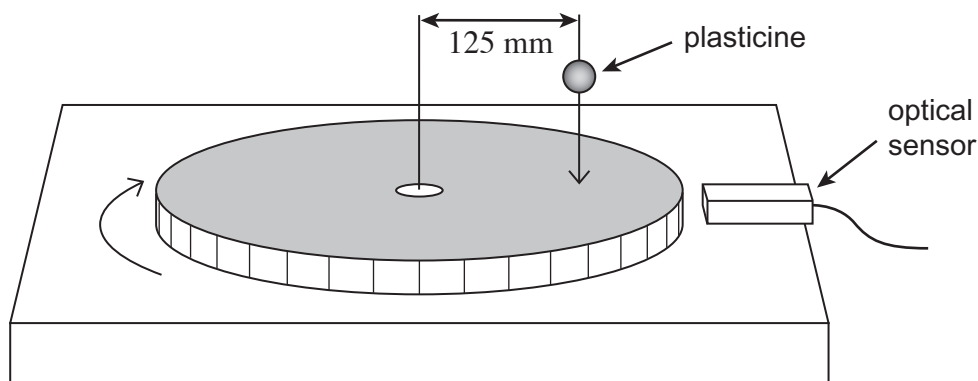
.....

.....



- 2 A student carries out an experiment to determine the moment of inertia of a turntable. **Figure 3** shows the turntable with a small lump of plasticine held above it. An optical sensor connected to a data recorder measures the angular speed of the turntable.

Figure 3



The turntable is made to rotate and then it rotates freely. The lump of plasticine is dropped from a small height above the turntable and sticks to it. Results from the experiment are as follows.

mass of plasticine = 16.0 g

radius at which plasticine sticks to the turntable = 125 mm

angular speed of turntable immediately before plasticine is dropped = 3.46 rad s^{-1}

angular speed of turntable immediately after plasticine is dropped = 3.31 rad s^{-1}

The student treats the plasticine as a point mass.

- 2 (a) Explain why the turntable speed decreases when the plasticine sticks to it.

[3 marks]

.....

.....

.....

.....

.....

.....

.....

.....



- 2 (b)** Use the results of the experiment to determine the moment of inertia of the turntable.
Give your answer to an appropriate number of significant figures.

[3 marks]

moment of inertia kg m²

- 2 (c) (i)** Calculate the change in rotational kinetic energy of the turntable and plasticine from the instant before the plasticine is dropped until immediately after it sticks to the turntable.

[2 marks]

change in kinetic energy J

- 2 (c) (ii)** Explain the change in rotational kinetic energy.

[1 mark]

.....

.....



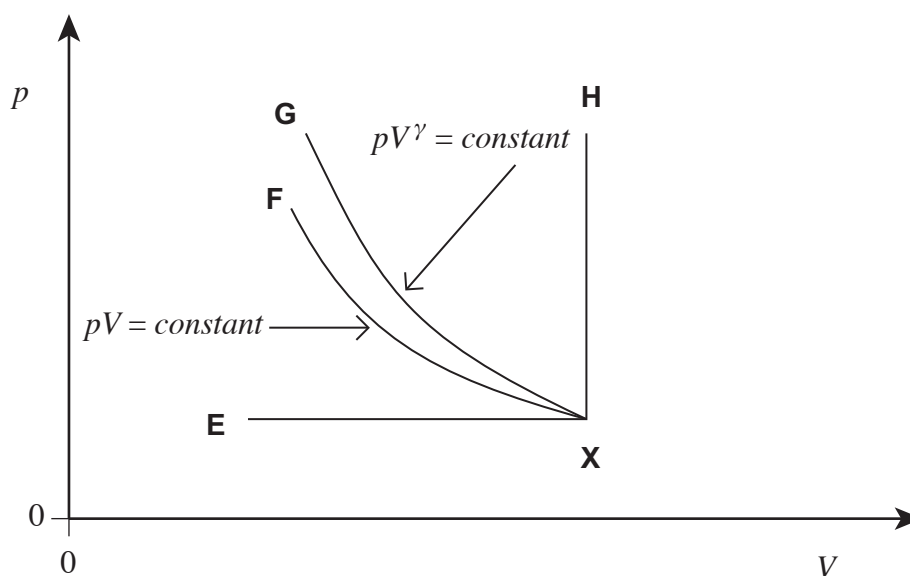
There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



- 3 (a)** A fixed mass of gas undergoes a change from one of states **E**, **F**, **G**, **H** to state **X** as shown on the pressure–volume (p – V) diagram in **Figure 4**.

Figure 4



Which change gives an increase in internal energy of the gas?
Tick (✓) the correct answer.

[1 mark]

E to X	
F to X	
G to X	
H to X	

Question 3 continues on the next page

Turn over ►



- 3 (b)** **Figure 5** shows a cross-section through the cylinder of a compressor used to supply air at high pressure to an air tank. The air tank is not shown. The high-pressure air in the tank is used to release and apply the brakes on a lorry.

On the outward stroke of the piston, air is drawn into the cylinder at atmospheric pressure through the inlet valve. The outlet valve remains closed. On the inward stroke, the inlet valve closes and the increasing pressure in the cylinder causes the outlet valve to open, forcing air into the tank. A small clearance volume exists when the piston is at the end of its inward stroke. The crankshaft of the pump is driven by the lorry engine by a gear wheel which acts as a flywheel.

Air is pumped into the air tank until the pressure reaches 8.0×10^5 Pa.

Figure 6 shows the idealised p – V diagram for one cycle in the initial stages of pumping, when the pressure in the air tank has reached approximately 4.5×10^5 Pa. The compressed air in the clearance volume at **C** must expand to point **D** before the inlet valve will open.

- 3 (b) (i)** The temperature of the air in the cylinder at the start of compression (point **A** on **Figure 6**) is 310 K.
Determine the temperature of the air at the point when the outlet valve is about to open. This is at point **B** on **Figure 6**.

[2 marks]

temperature K

- 3 (b) (ii)** Determine the net work done **on** the air during the cycle shown in **Figure 6**.

[3 marks]

work done J



Figure 5

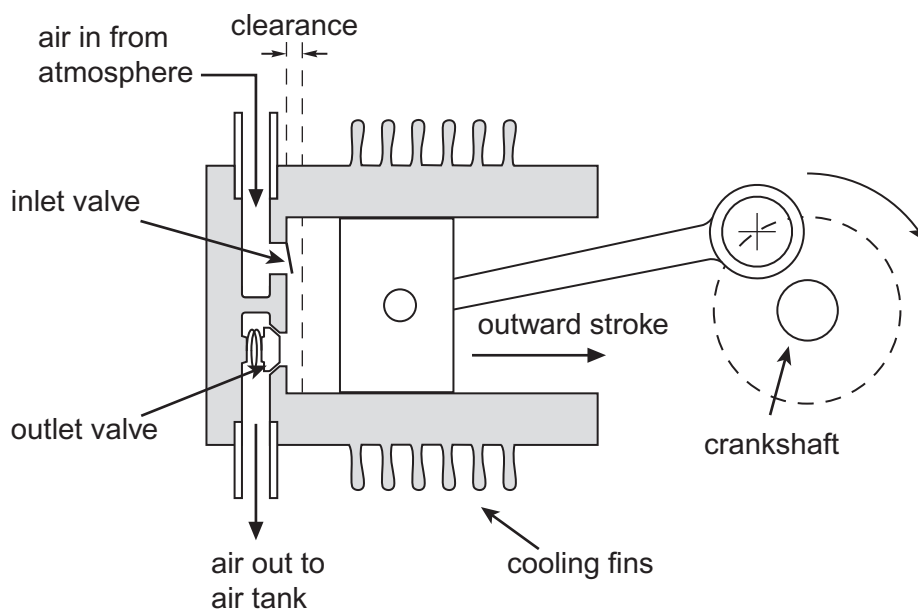
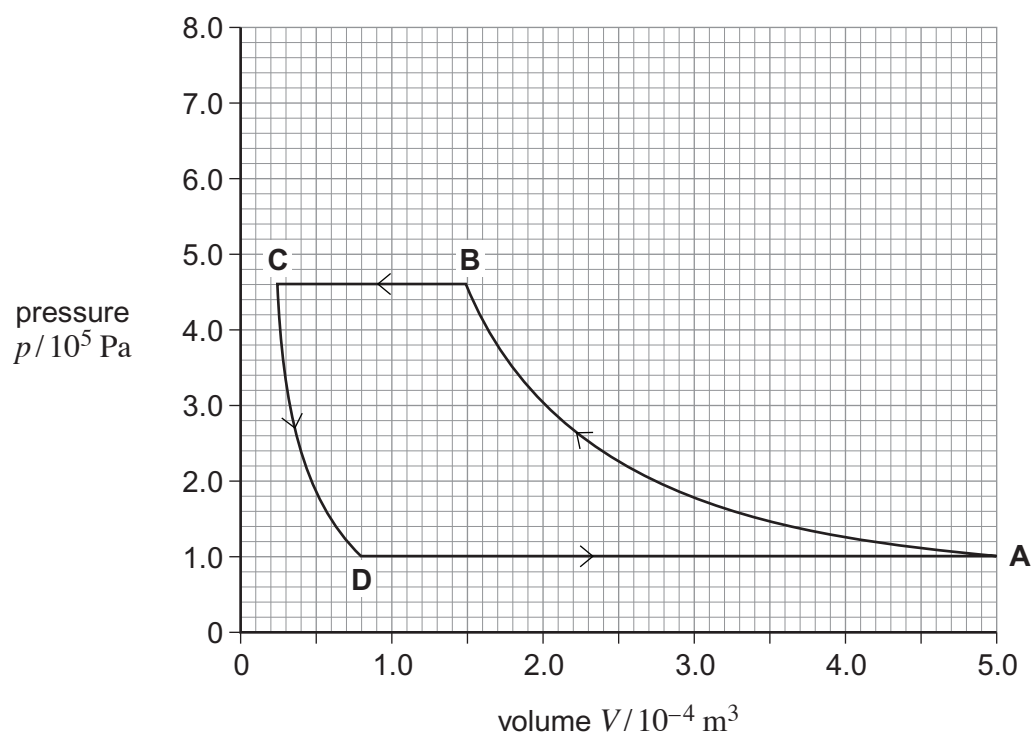


Figure 6



Question 3 continues on the next page

Turn over ►



- 3 (b) (iii) Determine the power input to the compressor when it runs at 420 revolutions per minute. [1 mark]

power W

- 3 (b) (iv) Explain how the performance of the air compressor changes as the pressure in the tank **increases**. Calculations are not expected.

In your answer you should consider:

- how and why the p – V diagram will change as the pressure in the tank increases
- how the temperature of the air in the cylinder changes
- the power input to the compressor, assuming it runs at constant speed
- the part played by the flywheel on the crankshaft.

The quality of your written communication will be assessed in your answer.

[6 marks]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



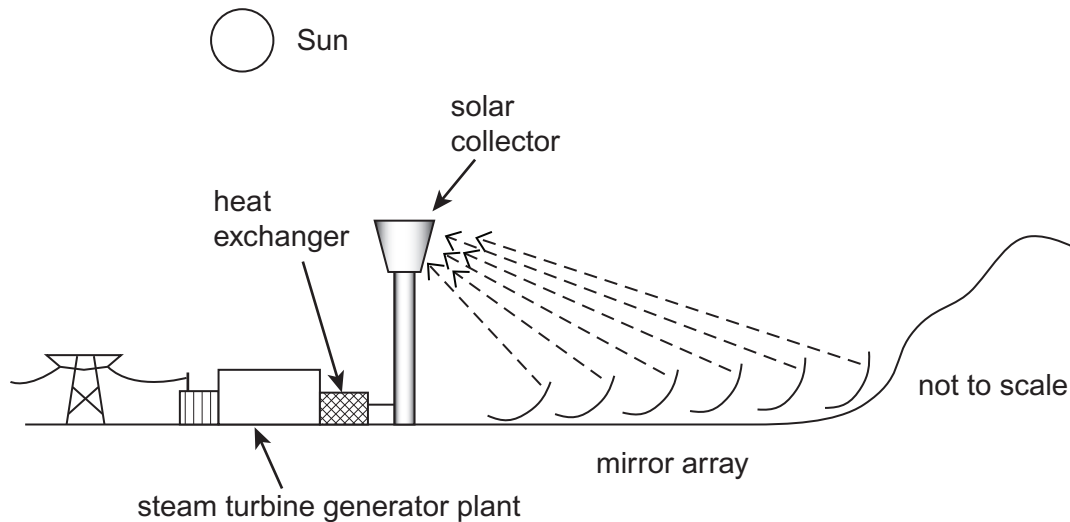
This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for handwriting practice or general writing. There are no margins, text, or other markings on the page.

Turn over ►



- 4** **Figure 7** shows the basic arrangement of a solar thermal power station. An array of mirrors tracks the Sun and reflects the Sun's rays onto a solar collector tower containing molten salt. The molten salt reaches a temperature of $540\text{ }^{\circ}\text{C}$. In the heat exchanger, the internal energy in the salt is transferred to water which turns to steam and drives a steam turbine generator to produce electricity. The steam turbine rejects energy to the atmosphere at $25\text{ }^{\circ}\text{C}$.

Figure 7



- 4 (a)** Calculate the maximum theoretical efficiency of a heat engine operating between temperatures of $540\text{ }^{\circ}\text{C}$ and $25\text{ }^{\circ}\text{C}$.

[2 marks]

maximum efficiency = ...



- 4 (b)** On one particular day the output of the power station is 48 MW. Calculate the input power to the power station assuming it can run at its maximum theoretical efficiency. **[1 mark]**

input power = ... W

- 4 (c)** The actual efficiency of the steam turbine is about 38% when the molten salt is at 540 °C. State **two** reasons why the actual efficiency of the power station is much less than the maximum theoretical efficiency. **[2 marks]**

- 1
-
-
- 2
-
-

END OF QUESTIONS



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



A-LEVEL

Physics

PHA5/2C – Applied Physics
Mark scheme

2450
June 2015

Version 1: Final mark scheme

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

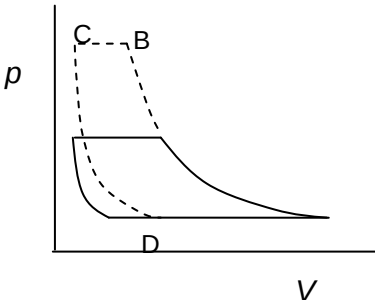
It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment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

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

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

Question	Answers	Additional Comments/Guidance	Mark	ID details
2 a	Law of conservation of <u>angular</u> momentum applies and $I_1 \omega_1 = I_2 \omega_2$ OR Law of conservation of <u>angular</u> momentum applies and angular momentum = $I \omega$ ✓ (because no external torque acts) Adding plasticine increases I ✓ So ω must decrease to maintain $I \omega$ constant / to conserve angular momentum ✓		3	
2 b	$I \times 3.46 = (I + 0.016 \times 0.125^2) \times 3.31$ ✓ $I = 0.00552 \text{ kg m}^2$ ✓ 3 sf ✓	Useful: $mr^2 = 2.5 \times 10^{-4}$ Sig fig mark s an independent mark 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	$\Delta E = \frac{1}{2}I\omega_1^2 - \frac{1}{2}(I+mr^2)\omega_2^2$ $= [\frac{1}{2} \times 5.52 \times 10^{-3} \times 3.46^2] - [\frac{1}{2} \times 5.77 \times 10^{-3} \times 3.31^2]$ ✓ $= 1.39 \times 10^{-3} \text{ J}$ ✓	CE for I of turntable or I of plasticine from 2b Answers will vary depending on rounding eg accept 1.43×10^{-3}	2	
2 c ii	Work done against friction/deforming plasticine as it collides with turntable/to move or accelerate plasticine ✓	Allow heat loss on collision 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	$p_1 V_1 / T_1 = p_2 V_2 / T_2$ $T_2 = p_2 V_2 T_1 / p_1 V_1 \quad \checkmark$ $= \frac{4.6 \times 10^5 \times 1.5 \times 10^{-4} \times 310}{1.0 \times 10^5 \times 5.0 \times 10^{-4}}$ $= 430 \text{ K} \quad \checkmark$	Also: work out n or nR in $p_1 V_1 = nRT_1$ Substitute in $p_2 V_2 = nRT_2$ Accept use of $4.5 \times 10^5 \text{ Pa}$ for p_2 Giving $T_2 = 420 \text{ K}$ $nR = 0.161$ $n = 1.94 \times 10^{-2}$	2	
3 b ii	Work per cycle = area enclosed by loop $\checkmark$ Suitable method for calculating area used correctly e.g. counting squares $\checkmark$ Correct scaling factor used leading to $70 \text{ J} \pm 5 \text{ J} \quad \checkmark$	e.g. $355 \text{ small sq} \times 0.2 \times 10^5 \times 0.1 \times 10^{-4}$ OR $14 \times 1 \text{ cm squares} \times 1.0 \times 10^5 \times 0.5 \times 10^{-4}$ If no. of squares incorrectly counted but correct scaling factor used for their squares give CE for final answer	3	
3 b iii	$P = 70 \times 420 / 60 = 500 \text{ W} \quad \checkmark$	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. <i>The candidate shows inadequate understanding of the operation of the compressor and how its performance will change.</i>	The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. <i>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.</i>	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. <i>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</i>	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. <i>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</i>	

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

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

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2014

Physics A

PHYA5/2C

Unit 5C Applied Physics
Section B

Thursday 19 June 2014 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 4 P H Y A 5 2 C 0 1

WMP/Jun14/PHYA5/2C/E5

STEMUP.CO.UK

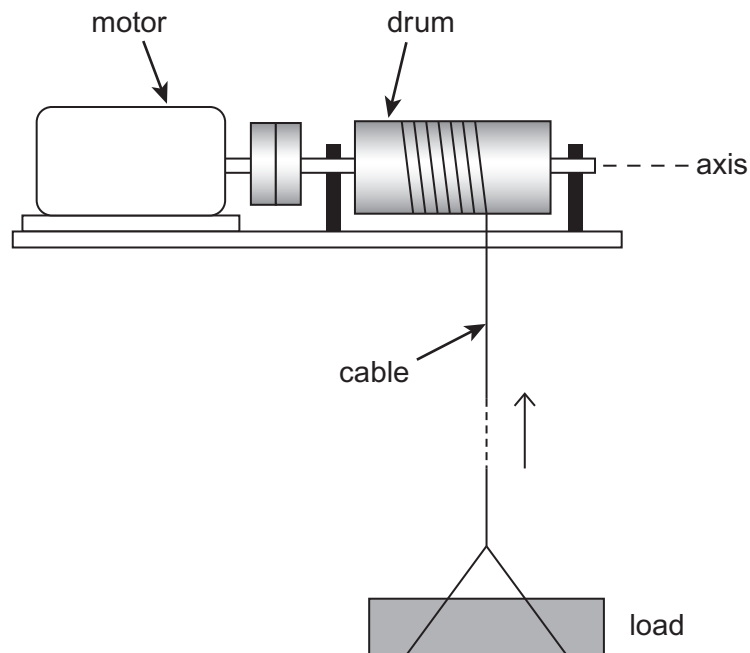
PHYA5/2C

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1** **Figure 1** shows a motor-driven winch for raising loads on a building site. As the motor turns the cable is wound around the drum, raising the load.

Figure 1



The drum, axle and other rotating parts have a moment of inertia about the axis of rotation of 7.4 kg m^2 , and the mass of the load is 85 kg . The drum has a radius of 0.088 m .

The load is accelerated uniformly from rest to a speed of 2.2 m s^{-1} . When it is accelerating it rises through a height of 3.5 m . It then continues at the constant speed of 2.2 m s^{-1} .

- 1 (a)** Show that the drum turns through 40 rad as the load accelerates.

[1 mark]



- 1 (b)** Calculate the angular speed of the drum when the load is moving at 2.2 m s^{-1} . **[1 mark]**

angular speed rad s^{-1}

- 1 (c) (i)** Show that for the time that the load is accelerating the total increase in energy of the load and the rotating parts is about 5400 J. **[3 marks]**

- 1 (c) (ii)** A constant frictional torque of 5.2 N m acts at the bearings of the winch.

Calculate the total work done by the motor to accelerate the load.

Give your answer to an appropriate number of significant figures.

[3 marks]

total work done J

Question 1 continues on the next page

Turn over ►



1 (d) Calculate the **maximum** power developed by the motor.

[2 marks]

maximum power W

10

Turn to page 6 for the next question



Turn over for the next question

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Turn over ►



2 In the sport of sprint cycling rapid acceleration is required.

Discuss the importance of moment of inertia in the design of sport cycle wheels. In your account you should:

- explain why it is desirable for the wheels to have a **low** moment of inertia when the cycle is required to accelerate rapidly
- explain the basic features of wheel design which would lead to a **low** moment of inertia about the axis of rotation.

The quality of your written communication will be assessed in your answer.

[6 marks]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

6

Turn over for the next question

Turn over ►



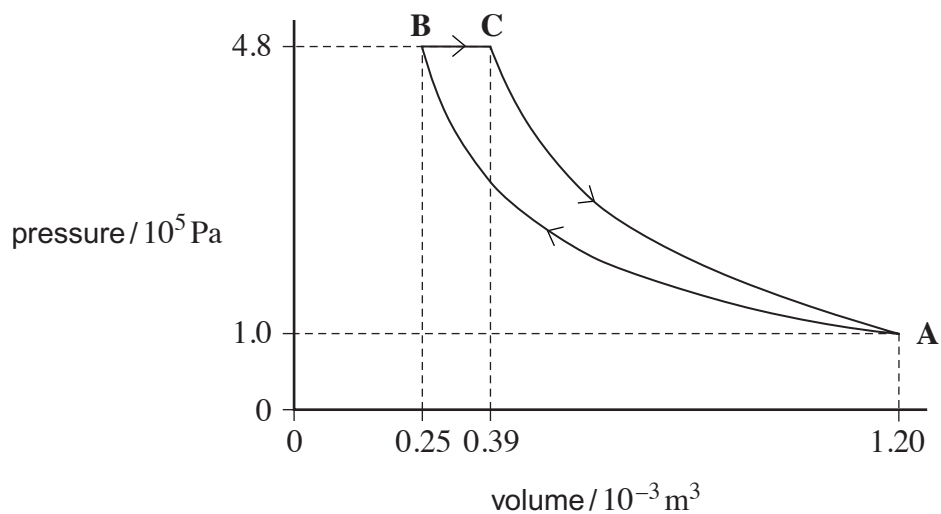
3 **Figure 2** shows a theoretical engine cycle in which a fixed mass of ideal gas is taken through the following processes in turn:

A → B: isothermal compression from volume $1.20 \times 10^{-3} \text{ m}^3$ and pressure $1.0 \times 10^5 \text{ Pa}$ to a volume $0.25 \times 10^{-3} \text{ m}^3$ and maximum pressure of $4.8 \times 10^5 \text{ Pa}$.

B → C: expansion at constant pressure with heat addition of 235 J

C → A: adiabatic expansion to the initial pressure and volume at **A**.

Figure 2



3 (a) (i) Show that process **A → B** is isothermal.

[2 marks]

3 (a) (ii) Calculate the work done by the gas in process **B → C**.

[1 mark]

work done J



- 3 (b)** Complete **Table 1**. Apply the first law of thermodynamics to determine values of Q , W and ΔU for each process and for the whole cycle. Use a consistent sign convention.

[3 marks]

Table 1

	Q / J	W / J	$\Delta U / \text{J}$
process A $\rightarrow$ B		-188	
process B $\rightarrow$ C	+235		
process C $\rightarrow$ A		+168	
whole cycle		+47	0

- 3 (c)** The overall efficiency of an engine is defined as

$$\frac{\text{net work output in one cycle}}{\text{energy supplied by heating from an external source in one cycle}}$$

Calculate the overall efficiency of the cycle.

[1 mark]

overall efficiency

- 3 (d)** Describe **two** problems that would be encountered in trying to design a real engine based on this cycle.

[2 marks]

.....

.....

.....

.....

.....



- 4 (a) Explain what is meant by the coefficient of performance of a heat pump.

[1 mark]

.....

.....

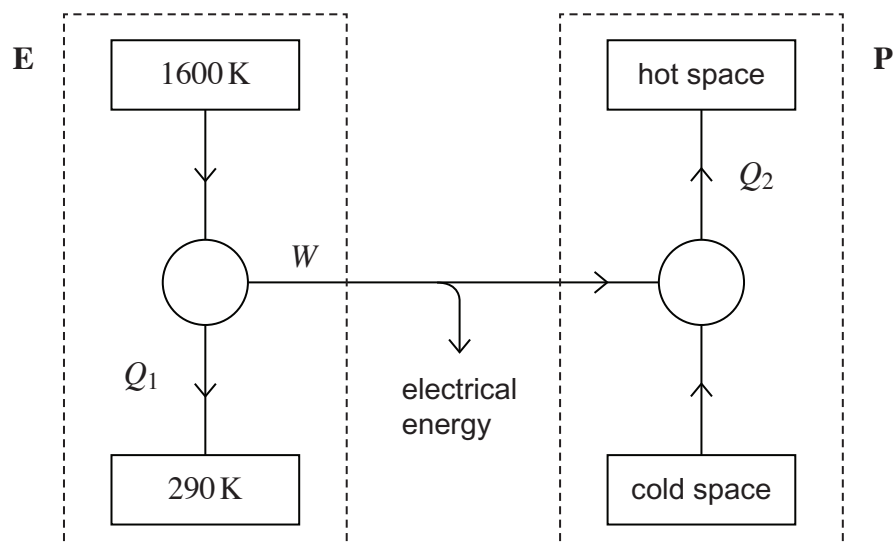
.....

.....

- 4 (b) The box labelled **E** in **Figure 3** shows a diagram of a combined heat and power scheme. The scheme provides electrical energy W from an engine-driven generator and heat Q_1 for buildings situated near to the generator.

Some of the electrical energy is used to drive the heat pump shown in the box labelled **P**. Output Q_2 is also used to heat the buildings.

Figure 3



You may assume that the engine runs at its maximum theoretical efficiency and that the electrical generator is 100% efficient. The output power of the engine-driven generator is 80 kW.



- 4 (b) (i)** The fuel used in the engine (**E**) is propane of calorific value 49 MJ kg^{-1} . Calculate the rate of flow of propane into the engine. State an appropriate unit.

[4 marks]

rate of flow unit

- 4 (b) (ii)** The heat pump has a coefficient of performance of 2.6.
The power supplied by the electrical generator to the heat pump (**P**) is 16 kW.
Calculate the total rate at which energy is available for heating from both the engine and heat pump.

[3 marks]

rate at which energy is available W

Question 4 continues on the next page

Turn over ►



- 4 (b) (iii) The conversion of electrical energy to heat is nearly 100% efficient. Explain why the designer has proposed installing a heat pump rather than an electrical heater to provide the additional heat Q_2 .

[2 marks]

.....

.....

.....

.....

.....

10

END OF QUESTIONS



A-LEVEL PHYSICS A

PHA5C – Applied Physics
Mark scheme

2450
June 2014

Version: 1.0 Final

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

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

Further copies of this Mark Scheme are available from aqa.org.uk

Question	Answers	Additional Comments/Guidance	Mark	ID details
1 a	$\frac{3.5}{(2\pi \times 0.088)} = 6.3 \text{ rev}$ $6.3 \times 2\pi = 39.8 \text{ rad}$ or 40 rad ✓ OR $\frac{3.5}{0.088} = 39.8$ or 40 rad ✓	If correct working shown with answer 40 rad give the mark Accept alternative route using equations of motion.	1	
1 b	$\omega = v/r = 2.2/0.088 = 25 \text{ rad s}^{-1}$ ✓		1	
1 c i	$E = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 + mgh$ $= (0.5 \times 7.4 \times 25^2)$ $+ (0.5 \times 85 \times 2.2^2)$ $+ (85 \times 9.81 \times 3.5)$ $= 2310 \text{ J}$ ✓ $+ 206 \text{ J}$ ✓ $+ 2920 \text{ J}$ ✓ $(= 5440 \text{ J or } 5400 \text{ J})$	CE from 1b $\frac{1}{2}I\omega^2 + \frac{1}{2}mv^2 = 2310 + 210 = 2520 \text{ J}$ $\frac{1}{2}I\omega^2 + mgh = 2310 + 2920 = 5230 \text{ J}$ $\frac{1}{2}mv^2 + mgh = 210 + 2920 = 3130 \text{ J}$ Each of these is worth 2 marks	3	
1 c ii	Work done against friction = $T\theta$ $= 5.2 \times 40 = 210 \text{ J}$ ✓ Total work done = $W = 5400 + 210$ $= 5600 \text{ J}$ ✓ 2 sig fig ✓	CE if used their answer to 1 c i rather than 5400J Accept 5700 J (using 5440 J) Sig fig mark is an independent mark	3	

1 d	Time of travel = distance /average speed = $3.5/1.1 = 3.2 \text{ s}$ ✓ $P_{\text{ave}} = \frac{5600}{3.2} = 1750 \text{ W}$ $P_{\text{max}} = P_{\text{ave}} \times 2 = 3500 \text{ W}$ ✓ OR accelerating torque = $T = W/\theta$ $= 5600/40 = 140 \text{ N m}$ ✓ $P = T \omega_{\text{max}} = 140 \times 25 = 3500 \text{ W}$ ✓	CE from 1c ii 1780 W if 5650 J used	2	
-----	--	---	---	--

question	answers	extra information	mark
2			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. <i>The candidate shows inadequate understanding of the concept of moment of inertia. Formulae may be quoted from the Formulae booklet, but the candidate is unable to apply their meaning to the question.</i>	The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. <i>The candidate shows little understanding of how M of I affects acceleration, probably confusing energy, momentum or torque, or treating this part of the question cursorily. They will probably relate M of I to mass and radius, but not cover the aspects of mass, and distribution of mass around the axis, and may not relate their answers well to the context of the question.</i> <u><i>There will be consideration of any 2 or 3 of the answer points below</i></u>	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. <i>Some attempt may be made to link energy, torque or momentum to acceleration, but understanding will be limited. They will link M of I to mass and radius² but may not cover all aspects of mass, and distribution of mass around the axis. They are likely to be able to suggest means of reducing M of I.</i> <u><i>At least any 4 of the answer points below are covered.</i></u>	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. <i>The candidate can explain the need for a low M of I for high acceleration by arguing coherently in terms of energy or torque or momentum, or a combination of these. They will relate their answer to cycles, and possibly specific sports.</i> <i>The candidate will show how $I = mr^2$ influences wheel design for low inertia, covering mass, and distribution of mass around the axis. They may also discuss optimizing low inertia with wheel strength or other design constraints.</i> <u><i>The answer includes at least one of the first 3 answer points below and any 5 others.</i></u>

examples of the points made in the response - Kinetic energy = $\frac{1}{2}I\omega^2$ so low I gives low stored energy, so less power needed to bring wheels (hence cycle) up to speed - Torque: $T = I\alpha$ so large torques needed (high push on pedals) unless I is small OR $T = I\alpha$ so for given torque low I means high acceleration. - Momentum: $T = \Delta(I\omega)/\text{time}$, so unless I small large time needed to bring to given angular speed for given torque $I = \Sigma mr^2$ explained AND/OR I depends on how mass is distributed - So for low I, low m / low density materials needed - of high strength e.g. carbon fibre - For low I, small radius helps, (but limited by design needs) - So low I if most of mass is near axle, and little mass far from axle - Hence use narrow tyres, low mass rims and tyres, spoke tensioners at hub etc..... - clearly relates linear acceleration to angular acceleration ($a = r\alpha$)		extra information . Must relate $I\omega$ to torque Accept 'lightweight' for 'low density' Either or both of high strength and named low density material e.g. gearing or pedalling problems Do not credit answers in terms of friction at the bearings. Even though this last point is not on the specification	

Question	Answers	Additional Comments/Guidance	Mark	ID details																									
3 a i	Clear statement that for isothermal $pV = \text{constant}$ or $p_1V_1 = p_2V_2$ ✓ Applies this to any 2 points on the curve AB ✓ e.g. $1.0 \times 10^5 \times 1.2 \times 10^{-3} = 4.8 \times 10^5 \times 0.25 \times 10^{-3}$ $120 = 120$	Allow $pV = c$ applied to intermediate points estimated from graph e.g. $V = 0.39 \times 10^{-3}$, $p = 3 \times 10^5$	2																										
3 a ii	$W = p \Delta v$ $= 4.8 \times 10^5 \times (0.39 - 0.25) \times 10^{-3}$ $= 67 \text{ J}$ ✓		1																										
3 b	<table border="1"> <thead> <tr> <th></th><th>Q/J</th><th>W/J</th><th>$\Delta U/J$</th><th></th></tr> </thead> <tbody> <tr> <td>process A → B</td><td>-188</td><td>-188</td><td>0</td><td>✓</td></tr> <tr> <td>process B → C</td><td>+235</td><td>(+)67</td><td>(+)168</td><td>✓</td></tr> <tr> <td>process C → A</td><td>0</td><td>+168</td><td>-168</td><td>✓</td></tr> <tr> <td>whole cycle</td><td>+47</td><td>+47</td><td>0</td><td>✓</td></tr> </tbody> </table>		Q/J	W/J	$\Delta U/J$		process A → B	-188	-188	0	✓	process B → C	+235	(+)67	(+)168	✓	process C → A	0	+168	-168	✓	whole cycle	+47	+47	0	✓	Any horiz line correct up to max 3. Give CE in B → C if ans to 3 a ii used for W If no sign take as +ve.	max 3	
	Q/J	W/J	$\Delta U/J$																										
process A → B	-188	-188	0	✓																									
process B → C	+235	(+)67	(+)168	✓																									
process C → A	0	+168	-168	✓																									
whole cycle	+47	+47	0	✓																									

3 c	$\eta_{\text{overall}} = 47/235 = 0.20$ or 20% ✓		1	
3 d	Isothermal process would require engine to run very slowly/ be made of material of high heat conductivity ✓ Adiabatic process has to occur very rapidly / require perfectly insulating container / has no heat transfer ✓ Very difficult to meet both requirements in the same device. ✓ Very difficult to arrange for heating to stop exactly in the right place (C) so that at end of expansion the curve meets the isothermal at A. ✓	Do not credit bald statement to effect adiabatic/isothermal process not possible - must give reason. Ignore mention of valves opening/closing, rounded corners, friction, induction /exhaust strokes. wtte	max 2	
Total			9	

Question	Answers	Additional Comments/Guidance	Mark	ID details
4 a	The ratio $\frac{\text{energy given to hot space/area to be heated}}{\text{work input}}$ ✓ OR $COP = Q_{IN}/W$ with Q_{IN} and W explained/defined ✓	It must be clear that Q_{IN} is energy delivered to the area to be heated/hot space. Do not accept 'heat input' or any wording that is vague.	1	
4 b i	$\eta_{\max} = \frac{1600 - 290}{1600} = 0.82/82\%$ ✓ input power = $\frac{\text{output power}}{\text{efficiency}} = \frac{80}{0.82} = 98 \text{ kW}$ ✓ fuel flow rate $\times CV = 98 \text{ kW}$ fuel flow rate = $98000/(49 \times 10^6) = 2.0 \times 10^{-3} \text{ kg s}^{-1}$ ✓ OR 7.2 kg h^{-1} ✓	If first 2 steps in calculation are not seen and 80 kW used for input power give 1 mark for: fuel flow rate = $80000/(49 \times 10^6) = 1.6 \times 10^{-3}$ ✓ The unit mark is an independent mark.	4	
4 b ii	$COP_{HP} = \frac{Q_2}{W}$ So $Q_2 = 16 \times 2.6 = 41.6$ or 42 kW ✓ $Q_1 = 98 - 80 = 18 \text{ kW}$ ✓ Total $Q_1 + Q_2 = 60 \text{ kW}$ ✓	CE for Q_1 if incorrect input power from b i is used, but NOT $80 - 16$ or $80 - 80$	3	
4 b iii	Heat pump delivers more heat energy than the electrical energy input. ✓		2	

	Reason: it <u>adds</u> energy from external source to electrical energy input. ✓	Accept $Q_{IN} = W + Q_{OUT}$ if explained correctly e.g. by diagram.		
--	--	---	--	--

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2013

Physics A

PHYA5/2C

**Unit 5C Applied Physics
Section B**

Thursday 20 June 2013 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 3 P H Y A 5 2 C 0 1

WMP/Jun13/PHYA5/2C

STEMUP.CO.UK

PHYA5/2C

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

1 The turntable of a microwave oven has a moment of inertia of $8.2 \times 10^{-3} \text{ kg m}^2$ about its vertical axis of rotation.

1 (a) With the drive disconnected, the turntable is set spinning. Starting at an angular speed of 6.4 rad s^{-1} it makes 8.3 revolutions before coming to rest.

1 (a) (i) Calculate the angular deceleration of the turntable, assuming that the deceleration is uniform. State an appropriate unit for your answer.

angular deceleration unit
(4 marks)

1 (a) (ii) Calculate the magnitude of the frictional torque acting at the turntable bearings.

torque Nm
(1 mark)

1 (b) The turntable drive is reconnected. A circular pie is placed centrally on the turntable. The power input to the microwave oven is 900 W, and to cook the pie the oven is switched on for 270 seconds. The turntable reaches its operating speed of 0.78 rad s^{-1} almost immediately, and the friction torque is the same as in part (a)(ii).

1 (b) (i) Calculate the work done to keep the turntable rotating for 270 s at a constant angular speed of 0.78 rad s^{-1} as the pie cooks.

work done J
(2 marks)



1 (b) (ii) Show that the ratio

$$\frac{\text{energy supplied to oven}}{\text{work done to drive turntable}}$$

is of the order of 10^5 .

(2 marks)

9

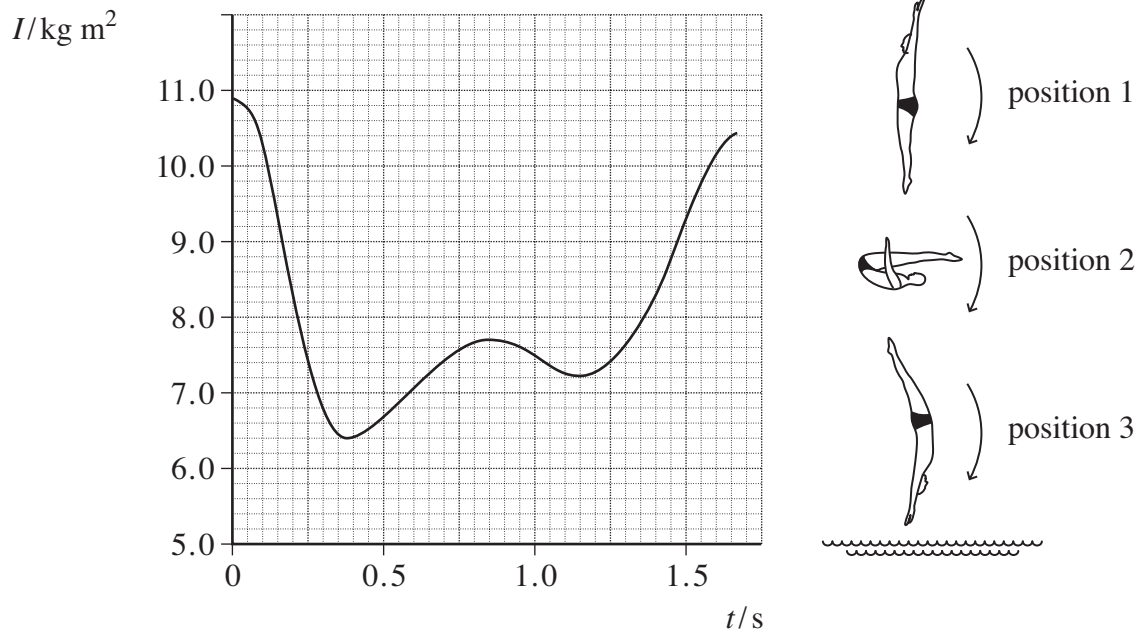
Turn over for the next question

Turn over ►



- 2 **Figure 1** shows how the moment of inertia I of a diver performing a reverse dive varies with time t from just after he has left the springboard until he enters the water.

Figure 1



The diver starts with his arms extended above his head (position 1), and then brings his legs towards his chest as he rotates (position 2). After somersaulting in mid-air, he extends his arms and legs before entering the water (position 3).

- 2 (a) Explain how moving the legs towards the chest causes the moment of inertia of the diver about the axis of rotation to decrease.

.....

.....

.....

.....

.....

.....

(2 marks)



- 2 (b) (i)** Explain in terms of angular momentum why the angular velocity of the diver varies during the dive.

.....

.....

.....

.....

.....

(2 marks)

- 2 (b) (ii)** Describe how the angular velocity of the diver varies throughout the dive.

.....

.....

.....

.....

(1 mark)

- 2 (c)** At time $t = 0$ the angular velocity of the diver is 4.4 rad s^{-1} and his moment of inertia about the axis of rotation is 10.9 kg m^2 .

With reference to **Figure 1** calculate the maximum angular velocity of the diver during the dive.

angular velocity rad s^{-1}
(3 marks)



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



- 3 (a)** Explain why the compression stroke of a diesel engine is considered to be an adiabatic change.

.....

.....

.....

.....

(2 marks)

- 3 (b)** **Figure 2** shows the cylinder of a diesel engine. The pressure of the air at the start of the compression stroke is $1.0 \times 10^5 \text{ Pa}$ and the volume above the piston is $4.5 \times 10^{-4} \text{ m}^3$.

Figure 2

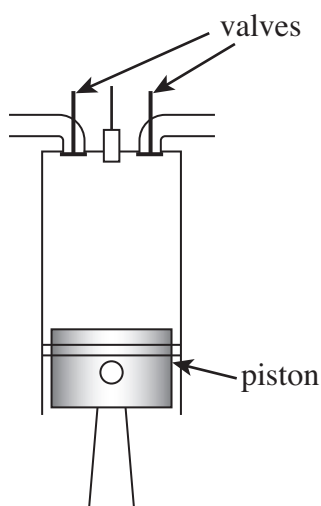


Figure 3

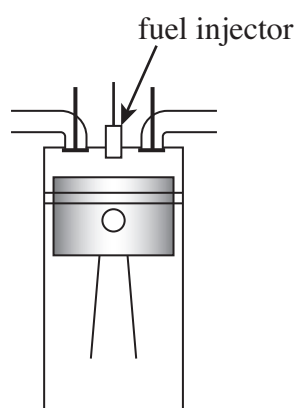


Figure 3 shows the same cylinder at the instant just before the fuel is injected. The pressure above the piston is now $6.2 \times 10^6 \text{ Pa}$. The compression is adiabatic with no leakage of air past the piston or valves.

adiabatic index γ for air = 1.4

- 3 (b) (i)** Calculate the volume above the piston at the instant just before the fuel is injected. Give your answer to an appropriate number of significant figures.

volume m^3
(3 marks)

Turn over ►



- 3 (b) (ii) The temperature of the air in the cylinder at the start of the compression stroke is 297 K. Calculate the temperature of the air at the instant just before the fuel is injected.

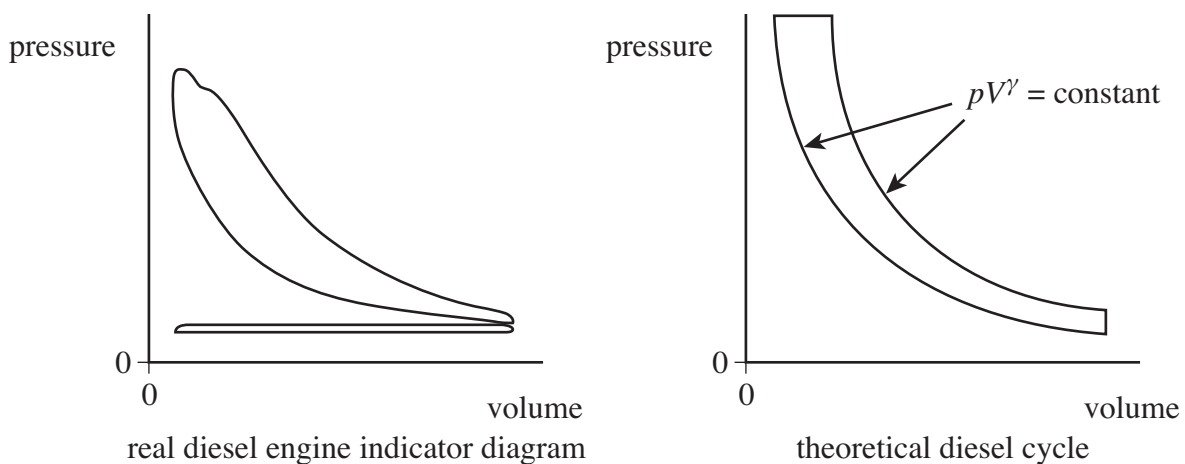
temperature K
(2 marks)

- 3 (b) (iii) Explain why, in a diesel engine, the fuel starts to be injected into the cylinder slightly before the piston reaches its highest point in the cylinder.

.....
.....
.....
(1 mark)

- 3 (c) **Figure 4** shows the indicator ($p - V$) diagram for a real diesel engine compared to the $p - V$ diagram for a theoretical diesel cycle of the same maximum and minimum volumes and fuel injection cut-off.

Figure 4



Compare the real engine cycle with the theoretical cycle. In your account you should:

- discuss the important differences between the cycles
- explain why the overall efficiency of the real engine is less than that predicted by an analysis of the theoretical cycle.

The quality of your written communication will be assessed in your answer.



This image shows a full page of white paper with horizontal dotted lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

14

4 (a) Explain what is meant by a reversed heat engine.

.....

.....

.....

.....

.....

(2 marks)

4 (b) Explain why the coefficient of performance of a reversed heat engine when operating as a heat pump is always greater than the coefficient of performance of the same reversed heat engine when operating as a refrigerator.

.....

.....

.....

.....

.....

.....

(2 marks)

4

END OF QUESTIONS



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright © 2013 AQA and its licensors. All rights reserved.





General Certificate of Education (A-level)
June 2013

Physics A

PHA5C

(Specification 2450)

Unit 5C: Nuclear and Thermal Physics

Applied Physics

Final

Mark Scheme

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised 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 students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this Mark Scheme are available from: aqa.org.uk

Copyright © 2013 AQA and its licensors. All rights reserved.

Copyright

AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

Section A – Nuclear and Thermal Physics

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)	(i)	1/12 the mass of an (atom) of $^{12}_6\text{C}$ / carbon-12 / C12✓	1	a reference to a nucleus loses the mark
1	(a)	(ii)	separated nucleons have a greater mass ✓ (than when inside a nucleus) because of the (binding) energy added to separate the nucleons or energy is released when a nucleus is formed (owtte) ✓	2	an answer starting with 'its' implies the nucleus marks are independent direction of energy flow or work done must be explicit
1	(b)		nuclei need to be close together (owtte) for the Strong Nuclear Force to be involved or for fusion to take place✓ but the electrostatic/electromagnetic force is repulsive (and tries to prevent this) ✓ (if the temperature is high then) the nuclei have (high) kinetic energy/speed (to overcome the repulsion) ✓	3	e.g. first mark – within the range of the SNF 3 rd mark is for a simple link between temperature and speed/KE
1	(c)	(i)	15 ✓ e^+ ✓ (or β^+ , $^0_1\beta$, ^0_1e) 12 ✓	3	give the middle mark easily for any e or β with a + in any position

1	(c)	(ii)	$\Delta\text{mass} = 4 \times 1.00728 - 4.00150 - (2 \times 9.11 \times 10^{-31} / 1.661 \times 10^{-27})$ or $\Delta\text{mass} = \{4 \times 1.00728 - 4.00150 - 2 \times 0.00055\}(\text{u}) \checkmark$ $\Delta\text{mass} = 0.02652(\text{u}) \checkmark$ $\Delta\text{binding energy} (= 0.02652 \times 931.5) \quad \{\text{allow } 931.3\}$ $\Delta\text{binding energy} = 24.7 \text{ MeV} \checkmark$	3	$(4 \times 1.00728 = 4.02912)$ 1 st mark – correct subtractions in any consistent unit. use of $m_p = 1.67 \times 10^{-27} \text{ kg}$ will gain this mark but will not gain the 2 nd as it will not produce an accurate enough result 2 nd mark – for calculated value 0.02652u $4.405 \times 10^{-29} \text{ kg}$ $3.364 \times 10^{-12} \text{ J}$ 3 rd mark – conversion to MeV conversion mark stands alone award 3 marks for answer provided some working shown – no working gets 2 marks (2sf expected)
2	(a)		insert control rods (further) into the nuclear core/reactor $\checkmark$ which will absorb (more) neutrons (reducing further fission reactions) $\checkmark$	2	a change must be implied for 2 marks marks by use of (further) or (more) allow answers that discuss shut down as well as power reduction If a statement is made that is wrong but not asked for limit the score to 1 mark (e.g. wrong reference to moderator)
2	(b)		fission fragments/daughter products or <u>spent/used</u> fuel/uranium rods (allow) plutonium (produced from U-238) $\checkmark$	1	not uranium on its own
2	(c)	(i)	γ (electromagnetic radiation is emitted) $\checkmark$ as the energy gaps are large (in a nucleus) as the nucleus de-excites down discrete energy levels to allow the nucleus to get to the ground level/state $\checkmark$ mark for reason	2	A reference to α or β loses this first mark 2 nd mark must imply energy levels or states

2	(c)	(ii)	momentum/<u>kinetic energy</u> is transferred (to the moderator atoms) or a neutron slows down/loses <u>kinetic energy</u> (with each collision) ✓ (eventually) reaching speeds associated with thermal random motion or reaches speeds which can cause fission (owtte)✓	2	
3		(i)	(heat supplied by glass = heat gained by cola) (use of $m_g c_g \Delta T_g = m_c c_c \Delta T_c$) $0.250 \times 840 \times (30.0 - T_f) = 0.200 \times 4190 \times (T_f - 3.0)$ ✓ $(210 \times 30 - 210 T_f = 838 T_f - 838 \times 3)$ $T_f = 8.4(1) (^{\circ}\text{C})$ ✓	2	1st mark for RHS or LHS of substituted equation 2nd mark for 8.4°C Alternatives: 8°C is substituted into equation (on either side shown will get mark)✓ resulting in 4620J~4190J ✓ or 8°C substituted into LHS ✓ (produces $\Delta T = 5.5^{\circ}\text{C}$ and hence) = 8.5°C ~ 8°C ✓ 8°C substituted into RHS✓ (produces $\Delta T = 20^{\circ}\text{C}$ and hence) = 10°C ~ 8°C ✓

3		(ii)	(heat gained by ice = heat lost by glass + heat lost by cola) (heat gained by ice = $mc\Delta T + ml$) heat gained by ice = $m \times 4190 \times 3.0 + m \times 3.34 \times 10^5$ ✓ (heat gained by ice = $m \times 346600$) heat lost by glass + heat lost by cola = $0.250 \times 840 \times (8.41 - 3.0) + 0.200 \times 4190 \times (8.41 - 3.0)$ ✓ (= 5670 J) $m (=5670/346600) = 0.016$ (kg) ✓ or (using cola returning to its original temperature) (heat supplied by glass = heat gained by ice) (heat gained by glass = $0.250 \times 840 \times (30.0 - 3.0)$) heat gained by glass = 5670 (J) ✓ (heat used by ice = $mc\Delta T + ml$) heat used by ice = $m(4190 \times 3.0 + 3.34 \times 10^5)$ ✓ (= $m(346600)$) $m (=5670/346600) = 0.016$ (kg) ✓	3	NB correct answer does not necessarily get full marks 3rd mark is only given if the previous 2 marks are awarded (especially look for $m \times 4190 \times 3.0$) the first two marks are given for the formation of the substituted equation not the calculated values if 8°C is used the final answer is 0.015 kg
4	(a)		molecules have negligible volume collisions are elastic the gas cannot be liquified there are no interactions between molecules (except during collisions) the gas obeys the (ideal) gas law / obeys Boyles law etc. at all temperatures/pressures any two lines ✓✓	2	a gas laws may be given as a formula
4	(b)	(i)	$n (= PV / RT) = 1.60 \times 10^6 \times 0.200 / (8.31 \times (273 + 22))$ ✓ = 130 or 131 mol ✓ (130.5 mol)	2	

4	(b)	(ii)	$\text{mass} = 130.5 \times 0.043 = 5.6 \text{ (kg)} \checkmark$ (5.61kg) $\text{density (= mass/volume)} = 5.61 / 0.200 = 28 \checkmark (28.1 \text{ kg m}^{-3})$ $\text{kg m}^{-3} \checkmark$	3	allow ecf from bi a numerical answer without working can gain the first two marks
---	-----	------	--	---	--

4	(b)	(iii)	$(V_2 = P_1 V_1 T_2 / P_2 T_1)$ $V_2 = 1.6 \times 10^6 \times .200 \times (273 - 50) / 3.6 \times 10^4 \times (273 + 22) \text{ or } 6.7(2)$ $(\text{m}^3) \checkmark$ $\text{mass remaining} = 5.61 \times 0.20 / 6.72 = 0.17 \text{ (kg)} \checkmark (0.167 \text{ kg})$ or $n = (PV / RT = 3.6 \times 10^4 \times 0.200 / (8.31 \times (273 - 50)) = 3.88(5) \text{ (mol)}$ $\checkmark$ $\text{mass remaining} = 3.885 \times 4.3 \times 10^{-2} = 0.17 \text{ (kg)} \checkmark$ 2 sig figs $\checkmark$	3	allow ecf from bii [reminder must see bii] look out for any 2 sf answer gets the mark
---	-----	-------	--	---	---

5		The mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC).		
	QWC	Descriptor	Mark range	
	High Level (Good to excellent)	The candidate refers to all the necessary apparatus and records the count-rate at various distances (or thicknesses of absorber). The background is accounted for and a safety precaution is taken. The presence of an α source is deduced from the rapid fall in the count rate at 2 – 5 cm in air. The presence of a γ source is deduced from the existence of a count-rate above background beyond 30 -50 cm in air (or a range in any absorber greater than that of beta particles, e.g. 3 – 6 mm in Al) or from the intensity in air falling as an inverse square of distance or from an exponential fall with the thickness of a material e.g. lead. <i>The information should be well organised using appropriate specialist vocabulary. There should only be one or two spelling or grammatical errors for this mark.</i>	5-6	If more than one source is used or a different experiment than the question set is answered limit the mark to 4

	Intermediate Level (Modest to adequate)	The candidate refers to all the necessary apparatus and records the count-rate at different distances (or thicknesses of absorber). A safety precaution is stated. The presence of an α source is deduced from the rapid fall in the count rate at 2 – 5 cm in air and the γ source is deduced from the existence of a count-rate beyond 30 -50 cm in air (or appropriate range in any absorber, e.g. 3 -6 mm in Al). Some safety aspect is described. One other aspect of the experiment is given such as the background. <i>The grammar and spelling may have a few shortcomings but the ideas must be clear.</i>	3-4	To get an idea of where to place candidate look for 6 items: 1. Background which must be used in some way either for a comparison or subtracted appropriately 2. Recording some data with a named instrument
	Low Level (Poor to limited)	The candidate describes recording some results at different distances (or thicknesses of absorber) and gives some indication of how the presence of α or γ may be deduced from their range. Some attempt is made to cover another aspect of the experiment, which might be safety or background. <i>There may be many grammatical and spelling errors and the information may be poorly organised.</i>	1 - 2	3. Safety reference appropriate to a school setting – not lead lined gown for example 4. Record data with more than one absorber or distances 5. α source determined from results taken 6. γ source determined
		The description expected in a competent answer should include a coherent selection of the following points. apparatus: source, lead screen, ruler, γ ray and α particle detector such as a Geiger Muller tube, rate-meter or counter and stopwatch, named absorber of varying thicknesses may be used. safety: examples include, do not have source out of storage longer than necessary, use long tongs, use a lead screen between source and experimenter. measurements: with no source present switch on the counter for a fixed period measured by the stopwatch and record the number of counts or record the rate-meter reading with the source present measure and record the distance between the source and detector (or thickness of absorber) then switch on the counter for a fixed period measured by the stopwatch and record the number of counts or record the rate-meter reading repeat the readings for different distances (or thicknesses of absorber).		from results taken this is a harder mark to achieve it may involve establishing an inverse square fall in intensity in air or an exponential fall using thicknesses of lead if a continuous distribution is not used an absorber or distance in air that would just eliminate β (30-50cm air / 3-6mm Al) must be used with and without the source being present or compared to background

		use of measurements: for each count find the rate by dividing by the time if a rate-meter was not used subtract the background count-rate from each measured count-rate to obtain the corrected count-rate longer recording times may be used at longer distances (or thickness of absorber). plot a graph of (corrected) count-rate against distance (or thickness of absorber) or refer to tabulated values plot a graph of (corrected) count-rate against reciprocal of distance squared or equivalent linear graph to show inverse square relationship in air analysis: the presence of an α source is shown by a rapid fall in the (corrected) count-rate when the source detector distance is between 2 – 5 cm in air the presence of a γ source is shown if the <u>corrected</u> count-rate is still present when the source detector distance is greater than 30 cm in air (or at a range beyond that of beta particles in any other absorber, e.g. 3 mm in Al) the presence of a γ source is best shown by the graph of (corrected) count-rate against reciprocal of distance squared being a straight line through the origin		
--	--	---	--	--

Section B – Applied Physics

Question	Part	Sub Part	Marking Guidance	Mark	Comments
1	(a)	(i)	$8.3 \text{ rev} = 8.3 \times 2\pi \text{ rad} \quad \checkmark \quad (= 52 \text{ rad})$ Use of $\omega_2^2 = \omega_1^2 + 2\alpha\theta$ $0 = 6.4^2 + 2 \times \alpha \times 52 \quad \checkmark$ OR use of $\theta = \frac{1}{2}(\omega_1 + \omega_2)t$ leading to $t = 16.25 \text{ s}$ and $\omega_2 = \omega_1 + \alpha t$ $\alpha = (-) 0.39 \quad \checkmark \quad \text{rad s}^{-2} \quad \checkmark$	4	If eqtn(s) of motion used correctly with $\theta = 8.3$ (giving $\alpha = 2.5$), give 2 out of first 3 marks. Accept : s^{-2} Unit mark is an independent mark
1	(a)	(ii)	$T = I\alpha$ $= 8.2 \times 10^{-3} \times 0.39 = 3.2 \times 10^{-3} \text{ N m} \quad \checkmark$	1	Give CE from a i
1	(b)	(i)	$(W = T\theta \text{ or } W = T\omega t) \quad \text{where } \theta = 0.78 \times 270 \quad \checkmark \quad (= 210 \text{ rad})$ $= 3.2 \times 10^{-3} \times 210 = 0.67 \text{ J} \quad \checkmark$	2	Give CE from a ii
1	(b)	(ii)	ratio = $\frac{900 \times 270}{0.67}$ or $\frac{2.4(3) \times 10^5}{0.67} \quad \checkmark$ $= 3.6 \times 10^5 \quad \checkmark$	2	CE from b i. Must be in the form: number $\times 10^5$ with number calculated correctly. 900×270 or $2.4(3) \times 10^5$ or equivalent must be seen for 1 st mark 1 mark for <u>only</u> writing 3.6×10^5
2	(a)		<u>Use of</u> $I = \Sigma mr^2$ or expressed in words $\checkmark$ With legs close to chest, more mass at smaller r , so I smaller $\checkmark$	2	
2	(b)	(i)	Angular momentum is conserved/must remain constant OR no external torque acts $\checkmark$ as I decreases, ω increases and vice versa to maintain $I\omega$ constant $\checkmark$ OR as I varies, ω must vary to maintain $I\omega$ constant	2	WTTE

2	(b)	(ii)	(Angular velocity increases initially then decreases (as he straightens up to enter the water)). With one detail point e.g. ✓ - Angular velocity when entering water is greater than at time $t = 0$ s. - Angular velocity increases, decreases, increases, decreases - Maximum angular velocity at $t = 0.4$ s - Greatest rate of change of ang. vel. is near the start - Angular velocity will vary as inverse of M of I graph	1	No mark for just ang. vel starts low then increases then decreases, i.e. for describing ω only at positions 1,2 and 3.
2	(c)		angular. momentum = $10.9 \times 4.4 = 48$ (N m s) ✓ ($\omega_{\max}$ occurs at minimum I) minimum $I = 6.4 \text{ kg m}^2$ (at 0.4 s) ✓ $6.4 \times \omega_{\max} = 48$ leading to $\omega_{\max} = 7.5 \text{ rad s}^{-1}$ ✓	3	Allow 6.3 to 6.5. If out of tolerance e.g. 6.2 give AE for final answer
3	(a)		(Adiabatic change requires) no heat transfer / energy transfer / heat to escape / heat loss (to surroundings) ✓ (Compression stroke occurs in short time/very quickly) so no time for heat transfer ✓ (Therefore change can be considered to be adiabatic)	2	Do not accept heat or energy 'change' .
3	(b)	(i)	$P_1 V_1^\gamma = P_2 V_2^\gamma$ $1.0 \times 10^5 \times (4.5 \times 10^{-4})^{1.4} = 6.2 \times 10^6 \times V_2^{1.4}$ ✓ $V_2 = 2.4 \times 10^{-5} \text{ m}^3$ ✓ 2 sig fig ✓	3	Significant figure mark is an independent mark

3	(b)	(ii)	use of $\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$ $T_2 = \frac{p_2 V_2 T_1}{p_1 V_1} = \frac{6.2 \times 10^6 \times 2.4 \times 10^{-5} \times 297}{1.0 \times 10^5 \times 4.5 \times 10^{-4}} \quad \checkmark$ OR use of $n = p_1 V_1 / RT_1$ and $T_2 = p_2 V_2 / nR$ Leading to $T_2 = 982 \text{ K}$ $\checkmark$	2	CE from b i If $2.36 \times 10^{-5} \text{ m}^3$ used for V_2, $T_2 = 966 \text{ K}$
3	(b)	(iii)	So that the fuel has partially evaporated/started to burn when piston is at top of stroke (so max pressure obtained when piston is at top of stroke/top dead centre). OR If injected at top dead centre. by the time fuel has started to burn, piston would be on its way down cylinder, (so max possible pressure not obtained).	1	Accept 'diesel' instead of 'fuel'
3	(c)		Good – Excellent 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. <i>The candidate gives a comprehensive account of the differences between the two cycles, with reasons. There are clear statements relating to the need for induction and exhaust processes/strokes in a real engine only, that adiabatic processes are not possible in the real engine, that constant pressure and constant volume processes are impossible, and/or that the corners of the real engine diagram are rounded.</i> <i>They will refer to the lower efficiency of the real engine, linking this to the smaller area loop, or the fact that the pumping loop has to be subtracted from the main loop and/or that heat transfers occur during compression and expansion and that in the real engine friction has to be overcome/power has to be expended in driving ancillaries.</i>	Mark Range 5-6	

			Modest – Adequate 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. <i>The candidate's comparisons are less complete but good understanding is shown of some of the major differences between the diagrams, with some reasons given.</i> <i>They should be able to give at least one valid reason for the lower efficiency of the real engine cycle.</i>	3-4	
			Poor – Limited The information conveyed by the answer is poorly organized and may not be relevant or coherent. There is little correct use of specialist vocabulary. <i>The candidate is more likely to describe the differences rather than explain them. They are likely to make reference to the rounded corners, and the induction/exhaust strokes in the 'real' diagram, but not be able to say why these do not exist in the theoretical diagram. They may not be able to give a valid reason for the lower efficiency of the real engine cycle, or may give vague reasons in terms of 'heat losses' or 'friction' without further detail.</i> The descriptions and explanations expected in a good answer should include several of the following physics ideas ▪ Real engine needs 'pumping loop' at near atmos. pressure for induction and exhaust ▪ Work needed for induction and exhaust –so efficiency lower than theoretical ▪ Area of pumping loop has to be subtracted from main loop, hence reducing net work and hence efficiency of real engine ▪ Theoretical cycle needs no pumping loop/same air continuously taken through repeated cycles	2-1	

			▪ Corners rounded on real engine diagram [because valves are needed and take finite time to open/close] ▪ Cooling cannot occur at constant volume in real engine [because piston would have to stop] ▪ Heating does not occur at constant pressure [because impossible to control rate of burning of fuel during injection] ▪ Compression and expansion do not take place infinitely quickly heat is lost; therefore not adiabatic processes, lowering efficiency ▪ Area of loop is smaller for real engine, less work done per cycle so lower efficiency ▪ Friction between moving surfaces has to be overcome /energy expended in driving oil and water pumps, opening and closing valves etc. ▪ Always some exhaust gases present in cylinder. ▪ Theoretical cycle does not make reference to any mechanism ▪ Calorific value of fuel is never fully realised		
4	(a)		(A device in which) an input of work ✓ (causes) heat to transfer from a cold space/reservoir to a hot space/reservoir ✓	2	

4	(b)	Heat transfer to hot space equals work done plus heat transfer from cold space/ $Q_{IN} = W + Q_{OUT}$ so Q_{IN} (is always) $> Q_{OUT}$ <i>reason must be seen</i> ✓ $COP_{HP} = \frac{Q_{IN}}{W}$ and $COP_{REF} = \frac{Q_{OUT}}{W}$ So $COP_{HP} > COP_{REF}$ ✓ OR $Q_{IN} = W + Q_{OUT}$ ✓ $COP_{HP} \times W = W + COP_{REF} \times W$ or $COP_{HP} = \frac{Q_{IN}}{W} = \frac{W + Q_{OUT}}{W}$ So $COP_{HP} = 1 + COP_{REF}$ So $COP_{HP} > COP_{REF}$ ✓	2	Either written statement or expressed in symbols The COP formulae are in formulae booklet so no marks for simply quoting them. i.e 2nd mark cannot be awarded without first mark.
---	-----	---	---	--

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2012

Physics A

PHYA5/2C

**Unit 5C Applied Physics
Section B**

Monday 18 June 2012 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 2 P H Y A 5 2 C 0 1

WMP/Jun12/PHYA5/2C

STEMUP.CO.UK

PHYA5/2C

Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1** **Figure 1** shows a child's 'pop' gun in which a piston is pushed quickly along the barrel, compressing the air in the barrel. When the pressure is high enough, the cork is expelled at high speed from the end of the barrel.

Figure 1

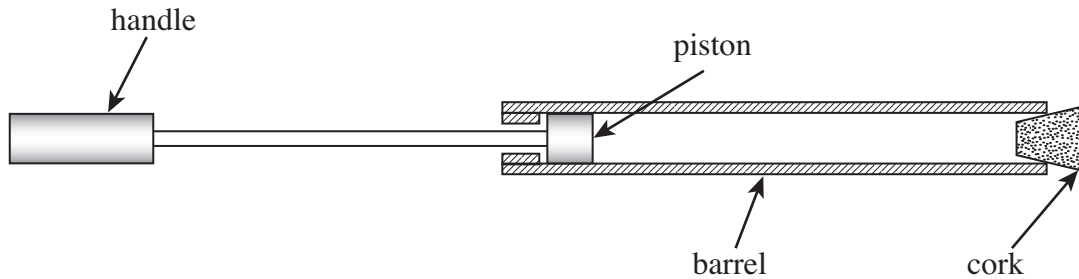


Figure 1 shows the gun before it is 'fired'. The air in the barrel is at a pressure of $1.0 \times 10^5 \text{ Pa}$, a temperature of 290 K and the volume is $2.1 \times 10^{-5} \text{ m}^3$.

- 1 (a) (i)** The volume of air in the barrel at the instant the cork is expelled is $1.2 \times 10^{-5} \text{ m}^3$. Calculate the pressure of the air in the barrel at the instant the cork is expelled. Assume that the air is compressed adiabatically.
adiabatic index, γ , for air = 1.4

answer = ... Pa
(2 marks)

- 1 (a) (ii)** Calculate the maximum temperature reached by the air in the gun. Give your answer to an appropriate number of significant figures.

answer = ... K
(3 marks)



- 1 (b)** The work needed to compress the air adiabatically from $2.1 \times 10^{-5} \text{ m}^3$ to $1.2 \times 10^{-5} \text{ m}^3$ is 1.4 J. Use the first law of thermodynamics to determine the change in internal energy of the air during the compression. Explain how you arrived at your answer.

answer = ... J
(2 marks)

- 1 (c)** Explain, giving your reasons, whether the volume of air in the barrel at the point when the cork leaves the gun would be less than, equal to, or greater than $1.2 \times 10^{-5} \text{ m}^3$ if the handle of the gun had been pushed in slowly. Assume there is no leakage of air past the cork or piston. You may find it helpful to sketch a $p - V$ diagram of the compression.

.....

.....

.....

.....

.....

.....

(3 marks)

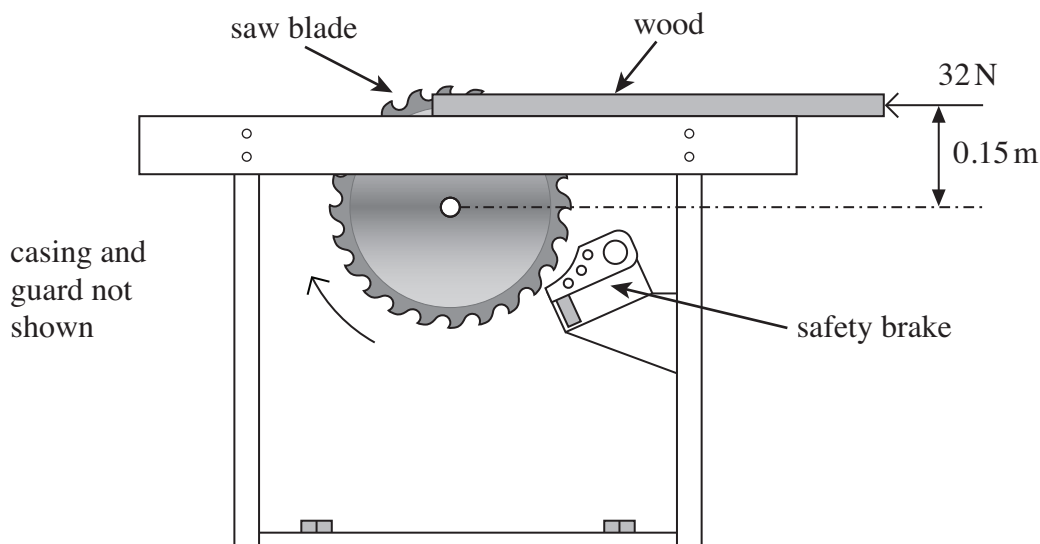
10

Turn over ►



- 2** **Figure 2** shows a type of circular saw. The blade is driven by an electric motor and rotates at $2600 \text{ rev min}^{-1}$ when cutting a piece of wood. A constant frictional torque of 1.2 N m acts at the bearings of the motor and axle.

Figure 2



A horizontal force of 32 N is needed to push a piece of wood into the saw. The force acts on the blade at an effective radius of 0.15 m .

- 2 (a) (i)** Calculate the torque on the saw blade resulting from the horizontal force on the wood.

answer = ... N m
(1 mark)

- 2 (a) (ii)** Calculate the output power of the motor when the saw is cutting the wood.

answer = ... W
(3 marks)



- 2 (b)** Immediately after cutting the wood the motor is switched off. The time taken for the saw blade to come to rest is 8.5 s. Calculate the moment of inertia of the rotating parts (i.e. the motor rotor, axle and blade). State an appropriate unit.

answer = ... unit = ...
(3 marks)

- 2 (c)** If the blade is accidentally touched when it is rotating, an electronic safety brake stops the blade in 5.0 ms. This is fast enough to prevent serious injury. The safety brake works by forcing a block of aluminium into the saw teeth.

Estimate the rate at which the rotational kinetic energy is dissipated as heat and in deforming the aluminium when the brake operates.

answer = ... W
(2 marks)

Turn over for the next question

Turn over ►



- 3 **Figure 3** shows a model steam engine used in a school to demonstrate energy transfers. The steam engine drives a dynamo which requires a constant torque. By means of valves, high pressure steam is applied to one side of the piston on the outward stroke (as shown) and to the other side of the piston on the inward stroke. The motion of the piston is converted to rotary motion by a connecting rod and crank. A flywheel (not shown) is fitted to the crankshaft.

Figure 3

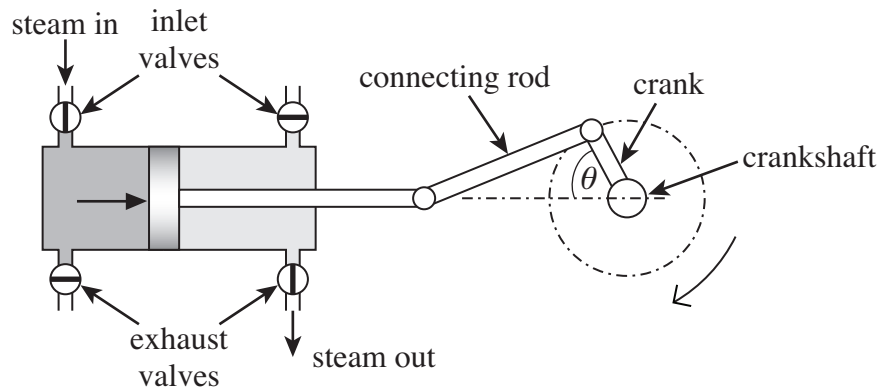
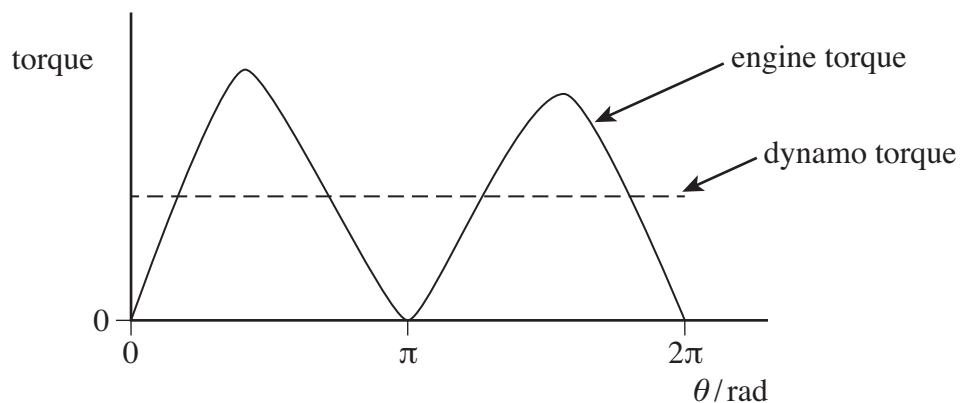


Figure 4 shows how the torque on the crankshaft due to the engine varies with the crankshaft angle θ for one rotation of the crankshaft. The broken line shows the constant dynamo torque required from the output.

Figure 4



- 3 (a) State and explain how you could use **Figure 4** to determine the work done by the engine in one revolution of the crankshaft.

.....

.....

.....

.....

(1 mark)



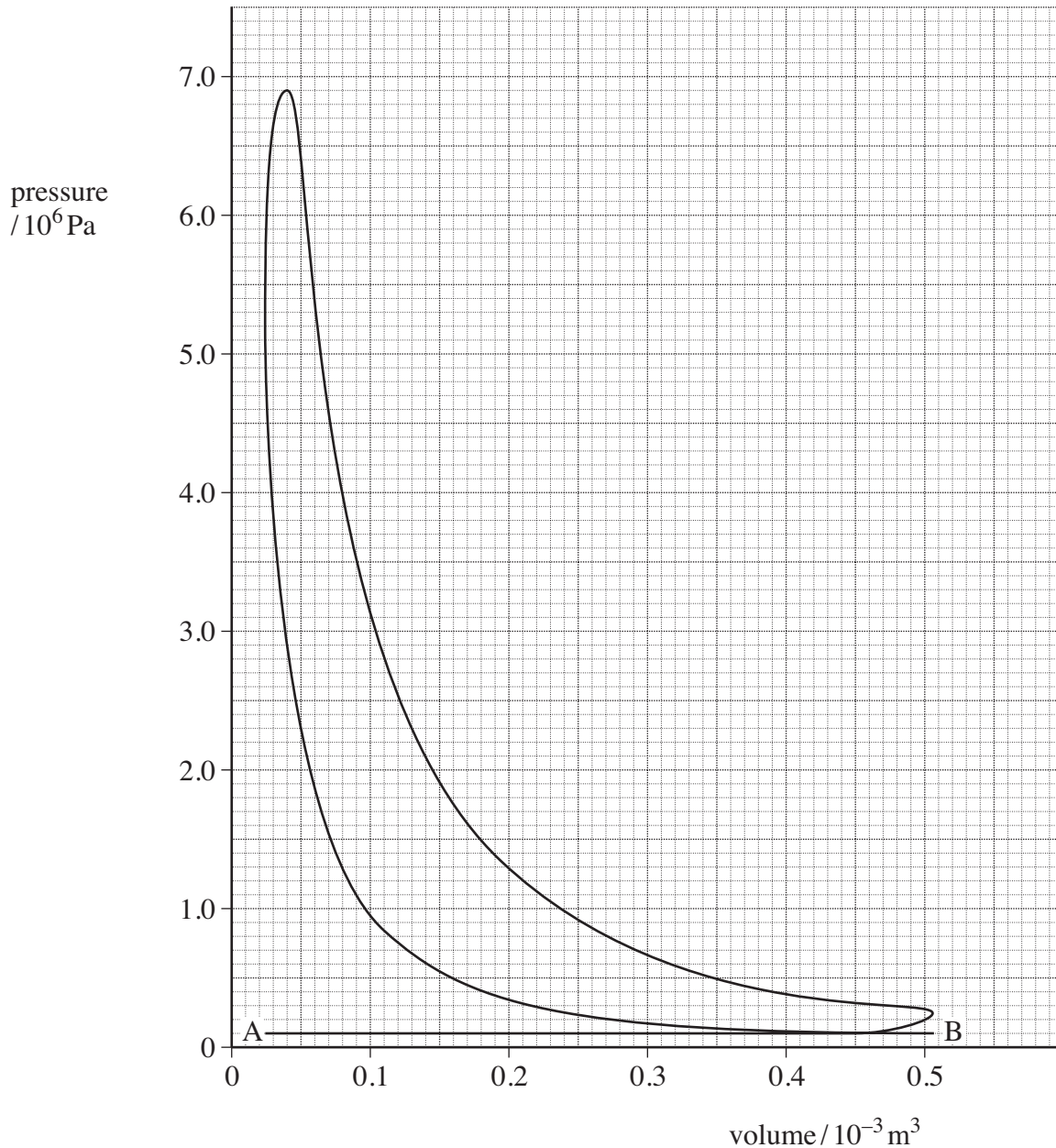
7



- 4 A four-stroke diesel engine with four cylinders is running at constant speed on a test bed. An indicator diagram for **one cylinder** is shown in **Figure 5** and other test data are given below:

measured output power of engine (brake power)	= 55.0 kW
fuel used in 100 seconds	= 0.376 litre
calorific value of fuel	= 38.6 MJ litre ⁻¹
engine speed	= 4100 rev min ⁻¹

Figure 5



- 4 (a) (i)** Determine the indicated power of the engine, assuming all cylinders give the same power.

answer = ... kW
(4 marks)

- 4 (a) (ii)** Calculate the overall efficiency of the engine.

answer = ...
(3 marks)

- 4 (b)** Account for the difference between the indicated power and brake power.

.....
.....
.....
(1 mark)

- 4 (c)** What is represented by the line AB on **Figure 5**?

.....
.....
(1 mark)

END OF QUESTIONS



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright © 2012 AQA and its licensors. All rights reserved.





General Certificate of Education (A-level)
June 2012

Physics A

PHYA5/2C

(Specification 2450)

Unit 5/2C: Applied Physics

Final

Mark Scheme

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process 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 standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised 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.

Further copies of this Mark Scheme are available from: aqa.org.uk

Copyright © 2012 AQA and its licensors. All rights reserved.

Copyright

AQA retains the copyright on all its publications. However, registered centres for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to centres to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; 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 scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. 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.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA5/1, Nuclear and Thermal Physics

1	a		$\Delta T = \left(\frac{\Delta Q}{mc}\right) = \frac{8.5 \times 10^3}{4200 \times 0.12} \checkmark$ 17 K $\checkmark$	2
1	b		$\left(\frac{\Delta T}{\Delta t} = \frac{\frac{\Delta Q}{mc}}{\Delta t}\right) = \frac{100 - 26}{\Delta t} = \frac{8.5 \times 10^3}{0.41 \times 4200} \checkmark$ $t = 15 \text{ s} \checkmark$	2
2	a		$({}^{206}_{76}\text{X} \rightarrow {}^{206}_{82}\text{Pb} + \beta \times {}^0_{-1}\beta + \beta \times \bar{\nu}_e)$ $\beta = 6 \checkmark$	1
2	b	i	the energy required to split up the nucleus $\checkmark$ into its individual neutrons and protons/nucleons $\checkmark$ (or the energy released to form/hold the nucleus $\checkmark$ from its individual neutrons and protons/nucleons $\checkmark$)	2
2	b	ii	$7.88 \times 206 = 1620 \text{ MeV} \checkmark$ (allow 1600-1640 MeV)	1
2	c	i	U, a graph starting at 3×10^{22} showing exponential fall passing through 0.75×10^{22} near 9×10^9 years $\checkmark$ Pb, inverted graph of the above so that the graphs cross at 1.5×10^{22} near 4.5×10^9 years $\checkmark$	2
2	c	ii	(u represents the number of uranium atoms then) $\frac{u}{3 \times 10^{22} - u} = 2$ $u = 6 \times 10^{22} - 2u \checkmark$ $u = 2 \times 10^{22}$ atoms	1
2	c	iii	(use of $N = N_0 e^{-\lambda t}$) $2 \times 10^{22} = 3 \times 10^{22} \times e^{-\lambda t} \checkmark$ $t = \ln 1.5 / \lambda$ (use of $\lambda = \ln 2 / t_{1/2}$) $\lambda = \ln 2 / 4.5 \times 10^9 = 1.54 \times 10^{-10} \checkmark$ $t = 2.6 \times 10^9 \text{ years} \checkmark$ (or $2.7 \times 10^9 \text{ years}$)	3
3	a		any 2 from: the sun, cosmic rays, radon (in atmosphere), nuclear fallout (from previous weapon testing), any radioactive leak (may be given by name of incident) nuclear waste, carbon-14 $\checkmark$	1

3	b	i	(ratio of area of detector to surface area of sphere) ratio = $\frac{0.0015}{4\pi(0.18)^2}$ ✓ 0.0037 ✓ (0.00368)	2
3	b	ii	activity = 0.62/(0.00368 × 1/400) give first mark if either factor is used. 67000 ✓ Bq accept s ⁻¹ or decay/photons/disintegrations s ⁻¹ but not counts s ⁻¹ ✓ (67400 Bq)	3
3	c		(use of the inverse square law) $\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$ or calculating k = 0.020 from I = k/x ² ✓ $I_2 = 0.62 \times \left(\frac{0.18}{0.28}\right)^2$ ✓ 0.26 counts s ⁻¹ ✓ (allow 0.24-0.26)	3
4	a	i	$n = PV/RT = 3.2 \times 10^5 \times 1.9 \times 10^{-3}/8.31 \times 285$ $n = 0.26$ mol ✓ (0.257 mol)	1
4	a	ii	$P_2 = \frac{T_2}{T_1} \times P_1 = \frac{295}{285} \times 3.20 \times 10^5$ ✓ 3.31×10^5 Pa ✓ (allow 3.30-3.35 × 10 ⁵ Pa) 3 sig figs ✓ sig fig mark stands alone even with incorrect answer	3
4	b		similar - (rapid) random motion - range of speeds different - mean kinetic energy - root mean square speed - frequency of collisions	2
5	a		graph starting (steeply) near/at the origin and decreasing in gradient ✓	1
5	b	i	(use of density = mass/volume) $\frac{197 \times 1.67 \times 10^{-27}}{\frac{4}{3}\pi(6.87 \times 10^{-15})^3}$ ✓✓ mark for top line and mark for bottom line (allow use of 1.66 × 10 ⁻²⁷) Lose mass line mark if reference is made to mass of electrons = 2.4(2) × 10 ¹⁷ kg m ⁻³	2

5	b	ii	$R_{A1} = R_{Au} \left(\frac{A_{A1}}{A_{Au}} \right)^{\frac{1}{3}} = 6.87 \times 10^{-15} \left(\frac{27}{197} \right)^{\frac{1}{3}} \checkmark$ $= 3.54 \times 10^{-15} \text{ m } \checkmark$ or $r_0 = \frac{R}{A^{\frac{1}{3}}} = \frac{6.87 \times 10^{-15}}{197^{\frac{1}{3}}} = 1.18 \times 10^{-15} \text{ m } \checkmark$ $R = 1.18 \times 10^{-15} \times 27^{\frac{1}{3}} = 3.54 \times 10^{-15} \text{ m } \checkmark$ or $\text{volume} = \text{mass/density} = \frac{27 \times 1.67 \times 10^{-27}}{2.42 \times 10^{17}} = \frac{4}{3} \pi \times R^3 \checkmark$ $= 3.54 \times 10^{-15} \text{ m } \checkmark$	2
5	c		The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate makes 5 to 6 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate makes 3 to 4 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate makes 1 to 2 points concerning the principles of the method, the limitations to the accuracy and the advantages and disadvantages of a particular method</i>	max 6

			The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences. principles • α scattering involves coulomb or electrostatic repulsion • electron diffraction treats the electron as a wave having a de Broglie wavelength • some reference to an equation, for example $\lambda = h/mv$; $eV = mv^2/2$; $Qq/4\pi\epsilon_0 r = E_\alpha$; $\sin\theta = 0.61\lambda/R$ • reference to first minimum for electron diffraction accuracy • α's only measure the least distance of approach, not the radius • α's have a finite size which must be taken into account • electrons need to have high speed/kinetic energy • to have a small wavelength or wavelength comparable to nuclear diameter, the wavelength determines the resolution • the wavelength needs to be of the same order as the nuclear diameter for significant diffraction • requirement to have a small collision region in order to measure the scattering angle accurately • importance in obtaining monoenergetic beams • cannot detect alpha particles with exactly 180° scattering • need for a thin sample to prevent multiple scattering advantages and disadvantages • α-particle measurements are disturbed by the nuclear recoil • Mark for α-particle measurements are disturbed by the SNF when coming close to the nucleus or electrons are not subject to the strong nuclear force. • A second mark can be given for reference to SNF if they add electrons are leptons or alpha particles are hadrons. • α's are scattered only by the protons and not all the nucleons that make up the nucleus • visibility – the first minimum of the electron diffraction is often difficult to determine as it superposes on other scattering events	
--	--	--	---	--

GCE Physics, Specification A, PHYA5/2C, Applied Physics

1	a	i	$p_2 = p_1 (V_2/V_1)^{1.4} = 1.0 \times 10^5 (2.1/1.2)^{1.4} \checkmark$ OR $1.0 \times 10^5 \times (2.1 \times 10^{-5})^{1.4} = p_2 \times ((1.2 \times 10^{-5})^{1.4} \checkmark$ $p_2 = 2.2 \times 10^5 \text{ Pa} \checkmark$	2
1	a	ii	$T_2 = \frac{p_2 V_2 T_1}{p_1 V_1} = \frac{2.2 \times 10^5 \times (1.2 \times 10^{-5}) \times 290}{1.0 \times 10^5 \times 2.1 \times 10^{-5}} \checkmark$ OR use of $p_1 V_1 = nRT_1$ to find n or nR and substitute in $p_2 V_2 = nRT_2$ to find $T_2 \checkmark$ $T_2 = 360 \text{ K} \checkmark$ 2 sig fig $\checkmark$	3
1	b		$(Q = W + \Delta U)$ $Q = 0$ (and W negative) $\checkmark$ So $\Delta U (= -W) = 1.4 \text{ J} \checkmark$	2
1	c		(slow) compression is (nearly) isothermal / at constant temperature $\checkmark$ greater change in volume needed to rise to same final pressure $\checkmark$ (OR correct p - V sketches showing adiabatic and isothermal processes $\checkmark$) hence less / piston pushed in further $\checkmark$	3
2	a	i	$T = Fr = 32 \times 0.15$ $= 4.8 \text{ N m} \checkmark$	1
2	a	ii	$\omega = 2600 \times 2\pi/60 (= 270 \text{ rad s}^{-1}) \checkmark$ accept 272 rad s^{-1} total torque $= 4.8 + 1.2 = 6.0 \text{ N m} \checkmark$ $P = T\omega$ $= 6.0 \times 270 = 1620 \text{ W} \checkmark$	3
2	b		$\alpha = \frac{270 - 0}{8.5} = 32 \text{ rad s}^{-2} \checkmark$ $I = T/\alpha = \frac{1.2}{32} = 0.038 \checkmark$ $\text{kg m}^2 \checkmark$ OR use of $\theta = \frac{1}{2}(\omega_2 + \omega_1)t (= 1150 \text{ rad}) \checkmark$ and $\frac{1}{2}I \omega^2 = T\theta$ leading to $I = 0.038 \checkmark$ $\text{kg m}^2 \checkmark$	3
2	c		$E = \frac{1}{2}I \omega^2$ $= 0.5 \times 0.038 \times 270^2 = 1400 \text{ J} \checkmark$ $P = E/t = 1400/0.005 = 280 \text{ kW} \checkmark$	2
3	a		Either $W = \text{area under (engine torque) graph from } 0 \text{ to } 2\pi \text{ rad} \checkmark$ OR $W = \text{area under graph because } W = T\theta \checkmark$ OR $W = \text{dynamo torque} \times 2\pi \checkmark$ OR $W = \text{area under dotted line / dynamo torque because } W = T\theta \checkmark$	1

3	b	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. <i>The candidate is aware that at two points in the cycle the engine torque is zero and can give a reason, perhaps mentioning moments or variation in steam pressure</i> <i>The candidate identifies the flywheel as a store of rotational kinetic energy and can relate the energy changes in one cycle to the varying torque and clearly relates the fluctuation in speed to the value of the M or I of the flywheel.</i> Alternatively, the candidate states that the flywheel tends to maintain angular momentum and so takes the crank over the dead centres. The changing torque has the effect of changing the angular momentum ($I\Delta\omega$) but if I is large, $\Delta\omega$ is small. <i>The candidate may go on to discuss effect of I being very large (e.g long acceleration time from start).</i> Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. <i>The candidate correctly identifies that a flywheel will make for smoother motion and may show an understanding that a flywheel acts as an energy reservoir, but may not be able to link the motion of the flywheel to the engine torque graph. Candidates answering in terms of angular momentum appreciate that the flywheel's angular momentum will take it over the dead centres. The candidate identifies that an increase in moment of inertia gives smoother running/less variation in speed per cycle. Reasons for the variation in torque may not refer to moments but candidate may state that torque is zero when crank and con rod are in line.</i> Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. <i>The candidate may be able to give a reason why the motion is not smooth and can identify that a flywheel will make for smoother running. There may be some reference to the flywheel storing energy. They may confuse power or angular momentum with energy.</i>	Max 6
---	---	---	------------------

			The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. • without flywheel motion will be jerky/unsmooth/cause vibrations OR flywheel makes motion smoother/less fluctuation in speed • flywheel needed to take crank over dead centres (wtte) • because torque is zero at dead centres • torque varies because pressure on piston varies • because force is in line with c'shaft/ no moment of force about c'shaft • flywheel stores rotational kinetic energy when engine torque > dynamo torque • flywheel gives up energy when engine torque < dynamo torque • flywheel's ang. momentum takes it over dead centres • the greater I, the less the fluctuation in speed over one cycle • over one cycle, work done by engine = work needed by dynamo • so average engine torque = average dynamo (load) torque • torque = rate of change of ang. momentum – high I gives less change in ω.	
4	a	i	Indicated work per cylinder = area of loop ✓ [either stated explicitly or shown on Fig 5 e.g. by shading or ticking squares or subsequent correct working.] appropriate method for finding area e.g. counting squares ✓ correct scaling factor used [to give answer of $470 \text{ J} \pm 50 \text{ J}$] ✓ indicated power = $4 \times 0.5 \times (4100/60) \times 470$ = 64 kW ✓	4
4	a	ii	(Fuel flow rate = $0.376/100 = 0.00376 \text{ litre s}^{-1}$) Input power (= c.v. $\times$ fuel flow rate) = $38.6 \times 10^6 \times 0.00376$ ✓ (= 145 kW) η_{overall} = brake power/input power ✓ seen or implied from correct subsequent working = $55.0/145 = 0.38$ or 38% ✓	3
4	b		Power expended in overcoming friction in (all) the bearings / between piston & cylinder ✓ and / or in circulating oil / cooling water ✓ and / or driving auxiliaries (e.g. fuel injection pump) ✓	Max 1

4	c		Represents the induction <u>and</u> exhaust (strokes) (which take place at nearly atmospheric pressure). ✓	1
---	---	--	--	---

UMS conversion calculator www.aqa.org.uk/umsconversion

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2011

Physics A

PHYA5/2C

**Unit 5C Applied Physics
Section B**

Monday 27 June 2011 9.00am to 10.45am

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet.

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



J U N 1 1 P H Y A 5 2 C 0 1

WMP/Jun11/PHYA5/2C

STEMUP.CO.UK

PHYA5/2C

Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

- 1 (a) State the law of conservation of angular momentum.

.....

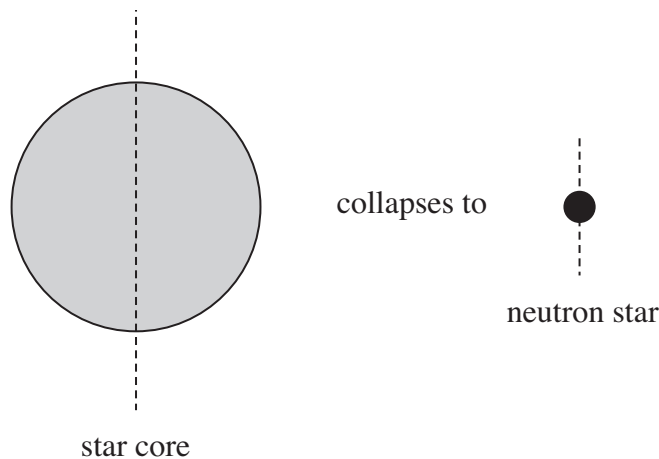
.....

.....

(1 mark)

- 1 (b) When a star undergoes a supernova explosion, the star's core collapses into a very much smaller diameter forming an extremely dense *neutron star* as shown in **Figure 1**.

Figure 1



A star has a period of rotation about an axis through its centre of 44 days (3.8×10^6 s) and a core of radius 4.1×10^7 m. The star undergoes a supernova explosion and the core collapses into a neutron star of radius 1.2×10^4 m.

You may assume that during the collapse no mass is lost from the core and that the star remains spherical.

Moment of inertia of a sphere of uniform mass m and radius R about an axis through its centre = $0.40mR^2$

- 1 (b) (i) Explain why the period of rotation of the star decreases as it becomes a neutron star.

.....

.....

.....

(2 marks)



- 1 (b) (ii)** Determine the period of rotation of the neutron star. Give your answer to an appropriate number of significant figures.

answer = ... s
(4 marks)

7

Turn over for the next question

Turn over ►



2 Some motor racing cars are fitted with a kinetic energy recovery system (KERS). In this system, as the car brakes approaching a bend, instead of all the lost kinetic energy being dissipated as heat, some of the energy is used to accelerate a flywheel. When the car needs to accelerate out of the bend, the energy in the flywheel assists the engine in providing extra power.

2 (a) Describe and explain some of the design features of a flywheel in order for it to store maximum energy. Your answer should include consideration of the flywheel's shape, the material from which it is made and its design for high angular speeds.

The quality of your written communication will be assessed in this question.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6 marks)



- 2 (b)** A KERS flywheel has a moment of inertia of 0.036 kg m^2 and rotates at its maximum angular speed of 6400 rad s^{-1} . When the flywheel is used to help accelerate the car, the flywheel's speed reduces uniformly to 3100 rad s^{-1} in a time of 6.6 s . You may assume that frictional losses in the drive mechanism are negligible.

- 2 (b) (i)** Calculate the energy transferred from the flywheel to the car.

answer = ... J
(1 mark)

- 2 (b) (ii)** Calculate the average power produced by the decelerating flywheel.

answer = ... W
(1 mark)

- 2 (b) (iii)** Calculate the decelerating torque on the flywheel, stating an appropriate unit.

answer = ...
(2 marks)

- 2 (b) (iv)** Calculate the number of revolutions made by the flywheel in the time of 6.6 s .

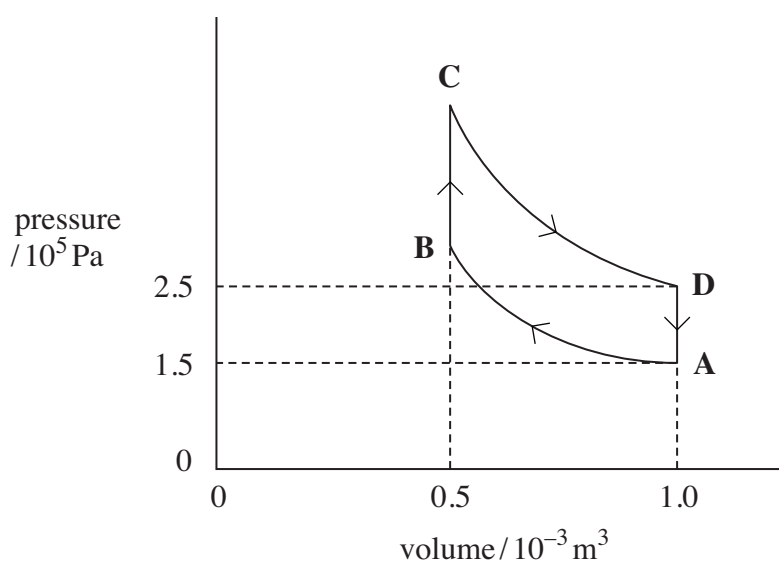
answer = ... revolutions
(2 marks)



- 3** In an ideal ‘hot air’ engine, a fixed mass of air is continuously taken through the following four processes:
- A → B isothermal compression at a temperature of 300 K. The work done on the air is 104 J.
 - B → C heating at constant volume.
 - C → D isothermal expansion. The work done by the expanding air is 173 J.
 - D → A cooling at constant volume.

The cycle is shown in **Figure 2**.

Figure 2



- 3 (a) (i)** Show that the temperature of the air at point D is 500 K.

(2 marks)

- 3 (a) (ii)** Apply the first law of thermodynamics to calculate the energy supplied by heat transfer in process C → D.

answer = ... J
(2 marks)



- 3 (b)** The engine contains a device called a regenerator which stores **all** the energy rejected by cooling in process $D \rightarrow A$ and gives up **all** this energy to the air again in process $B \rightarrow C$. This means that energy must be supplied to the air by heat transfer from an external source **only** in process $C \rightarrow D$.

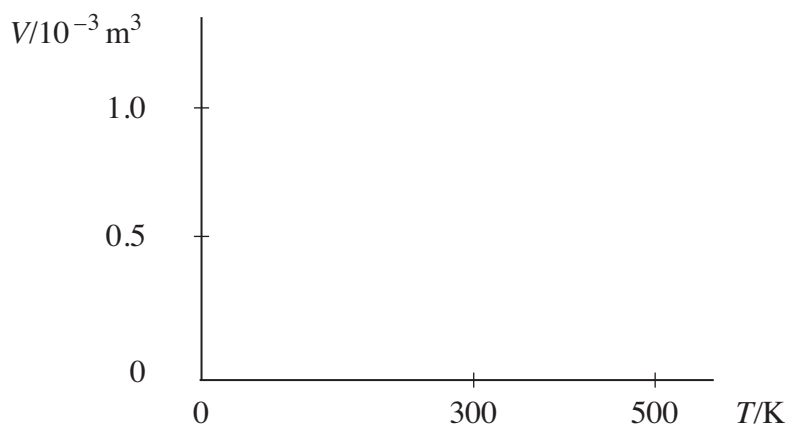
- 3 (b) (i)** Calculate the net work done during the cycle.

answer = ... J
(1 mark)

- 3 (b) (ii)** Show that the efficiency of the cycle is the same as the maximum possible efficiency of any heat engine operating between the same highest and lowest temperatures in the cycle.

(2 marks)

- 3 (c)** On the axes below, sketch the cycle on a graph of volume V against temperature T . Label the points A, B, C and D.



(2 marks)

Question 3 continues on the next page

Turn over ►



- 3 (d)** Several inventors have tried to build an engine that works on this cycle. Give **two** reasons why they have been unsuccessful.

.....

.....

.....

.....

.....

(2 marks)

11



- 4** A heat pump is used for heating a small workshop. The heat pump extracts energy from a patch of ground outside the workshop. The coefficient of performance of the heat pump is 3.2 and the average electrical power input is 780 W.

- 4 (a) (i)** Calculate the rate at which energy is delivered to the workshop.

answer = ... W
(1 mark)

- 4 (a) (ii)** Calculate the rate at which energy is extracted from the ground.

answer = ... W
(1 mark)

- 4 (b)** A student claims: "A heat pump delivers more energy than is supplied to it". Discuss this statement and explain why a heat pump does not contradict the law of conservation of energy or the second law of thermodynamics.

.....

.....

.....

.....

.....

.....

.....

(3 marks)

5

END OF QUESTIONS



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright © 2011 AQA and its licensors. All rights reserved.





General Certificate of Education (A-level)
June 2011

Physics A

PHYA5/2C

(Specification 2450)

Unit 5/2C: Applied Physics

Final

Mark Scheme

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 events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process 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 standardisation each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised 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.

Further copies of this Mark Scheme are available from: aqa.org.uk

Copyright © 2012 AQA and its licensors. All rights reserved.

Copyright

AQA retains the copyright on all its publications. However, registered centres for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to centres to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Set and published by the Assessment and Qualifications Alliance.

The Assessment and Qualifications Alliance (AQA) is a company limited by guarantee registered in England and Wales (company number 3644723) and a registered charity (registered charity number 1073334).
Registered address: AQA, Devas Street, Manchester M15 6EX.

Instructions to Examiners

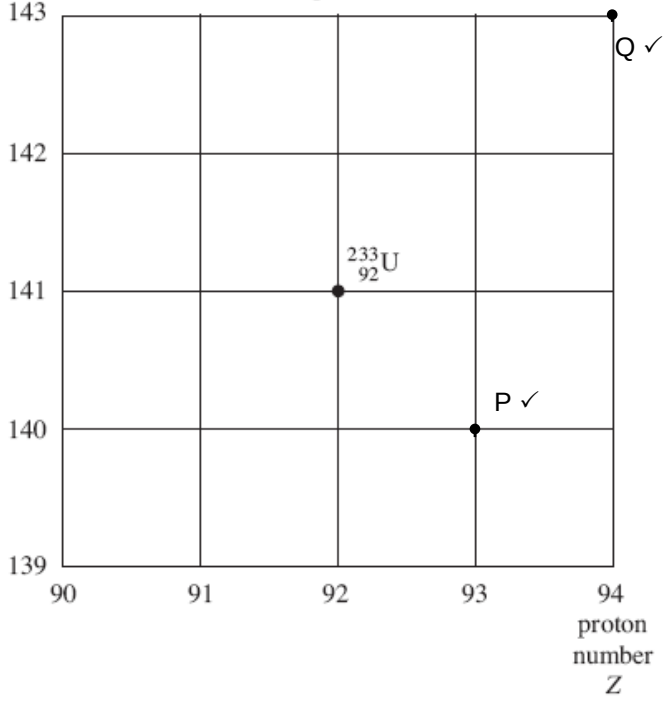
- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; do not deduct marks because the attempt falls short of some ideal answer. Where marks are to be deducted for particular errors, specific instructions are given in the marking scheme.
- 2 Do not deduct marks for poor written communication. Refer the scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

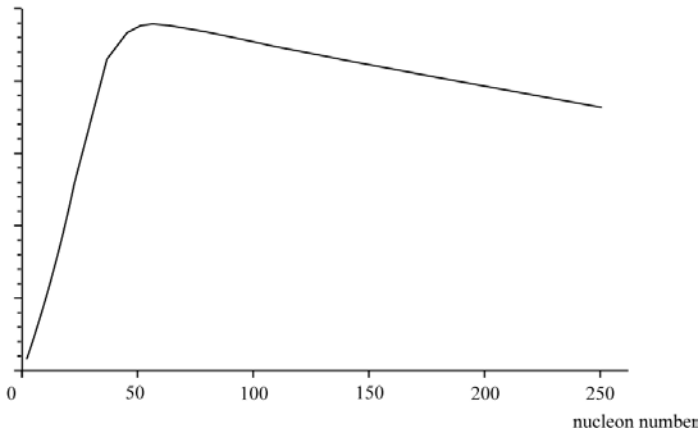
Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. 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.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

GCE Physics, Specification A, PHYA5/1, Nuclear and Thermal Physics

Question 1		
a	${}_{91}^{233}\text{Pa}$ ✓ anti (electron) neutrino ✓	2
b		2
c i	$x = 4$ ✓	1
c ii	mass defect = $[(232.98915 + 1.00867) - (90.90368 + 138.87810 + 4 \times 1.00867)] \text{ u}$ ✓ $= 0.18136 \text{ u}$ ✓ energy released $(= 0.18136 \times 931) = 169 \text{ (MeV)}$ ✓	3
Total		8

Question 2		
a	${}_{13}^{27}\text{Al} + \alpha \rightarrow {}_{15}^{30}\text{P} + {}_0^{(1)}\text{n}$ ✓	1
b	kinetic energy lost by the α particle approaching the nucleus is equal to the potential energy gain ✓ $2.18 \times 10^{-12} = \frac{1}{4\pi \times 8.85 \times 10^{-12}} \times \frac{13 \times 1.6 \times 10^{-19} \times 2 \times 1.6 \times 10^{-19}}{r}$ ✓ $r = 2.75 \times 10^{-15} \text{ (m)}$ ✓	3
Total		4

Question 3		
a	binding energy per nucleon  peak 8.7 (accept 8.0 – 9.2) ✓ in MeV ✓ (or peak 1.4×10^{-12} accept $1.3 - 1.5 \times 10^{-12}$ ✓ in J ✓) at nucleon number 50 – 60 ✓ accept 50 – 75 sharp rise from origin and moderate fall not below 2/3 of peak height ✓	4
b	energy is released/made available when binding energy per nucleon is increased ✓ in fission a (large) nucleus splits and in fusion (small) nuclei join ✓ the most stable nuclei are at a peak ✓ fusion occurs to the left of peak and fission to the right ✓	max 3
Total		7

Question 4		
a	(use of $\Delta Q = mc\Delta T$) $30 \times 98 = 0.100 \times c \times 14$ ✓ $c = 2100 \text{ (J kg}^{-1} \text{ K}^{-1}\text{)}$ ✓	2
b	(use of $\Delta Q = ml + mc\Delta T$) $500 \times 98 = 0.100 \times 3.3 \times 10^5$ ✓ + $0.100 \times 4200 \times \Delta T$ ✓ $(\Delta T = 38^\circ\text{C})$ $T = 38^\circ\text{C}$ ✓	3
c	the temperature would be higher ✓ as the ice/water spends more time below 25°C or heat travels in the direction from hot to cold or ice/water first gains heat then loses heat any one line ✓	2
Total		7

Question 5		
a	graph passes through given point $2.2 \times 10^{-3} \text{ m}^3$ at 0°C straight line with positive gradient ✓ (straight) line to aim or pass through -273°C at zero volume ✓	2
b	(use of $n = P V / R T$) $1.00 \times 10^5 \times 2.20 \times 10^{-3} / 8.31 \times 273$ ✓ $n = 0.0970$ (moles) ✓	2
c	(use of mean kinetic energy = $3/2 K T$) $= 3/2 \times 1.38 \times 10^{-23} \times 323$ ✓ 6.69×10^{-21} (J) ✓ 3 sfs ✓	3
d	total internal energy = $6.69 \times 10^{-21} \times 0.0970 \times 6.02 \times 10^{23} = 390$ (J) ✓	1
e	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and coherent sequence of ideas linking the motion of molecules to the pressure they exert on a container. At least three of the first four points listed below must be given in a logical order. The description should also show awareness of how a balance is maintained between the increase in speed and shortening of the time interval between collisions with the wall to maintain a constant pressure. To be in this band, reference must be made to force being the rate of change of momentum or how, in detail, the volume compensates for the increase in temperature. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides a comprehensive list of ideas linking the motion of molecules to the pressure they exert on a container. At least three of the first four points listed below are given. The candidate also knows that the mean square speed of molecules is proportional to temperature. Using this knowledge, an attempt is made to explain how the pressure is constant.	max 6

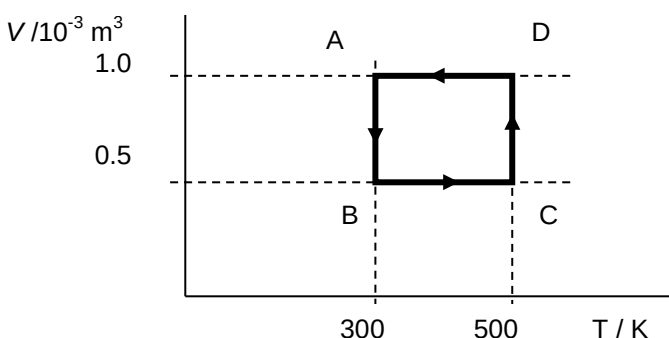
	Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate attempts the question and refers to at least two of the points listed below. Incorrect, inappropriate or no response: 0 marks No answer or answer refers to unrelated, incorrect or inappropriate physics. Statements expected in a competent answer should include some of the following marking points. molecules are in rapid random motion/many molecules are involved molecules change their momentum or accelerate on collision with the walls reference to Newton's 2nd law either $F = ma$ or $F = \text{rate of change of momentum}$ reference to Newton's 3rd law between molecule and wall relate pressure to force $P = F/A$ mean square speed of molecules is proportional to temperature as temperature increases so does change of momentum or change in velocity compensated for by longer time between collisions as the temperature increases as the volume increases the surface area increases which reduces the pressure	
	Total	14

GCE Physics, Specification A, PHYA5/2C, Applied Physics

Question 1		
a	the (total) angular momentum (of a system) remains constant provided no external torque acts (on the system) ✓	1
b i	(as core radius decreases M of I of core decreases) / ω must remain constant ✓ I decreases so ω increases and greater ω means shorter period of rotation or less time for one revolution ✓	2
b ii	$0.4 m R_1^2 \times 2\pi/T_1 = 0.4 m R_2^2 \times 2\pi/T_2$ ✓ $T_2/T_1 = R_2^2/R_1^2$ ✓ $T_2 = \frac{(12 \times 10^3)^2}{(4.1 \times 10^7)^2} \times 3.8 \times 10^6$ $= 0.33 \text{ s}$ ✓ 2 sf ✓ or $0.4 m \times (4.1 \times 10^7)^2 \times \omega_1$ $= 0.4 m \times (12 \times 10^3)^2 \times \omega_2$ ✓ $\omega_1 = 2\pi/T = 2\pi/(3.8 \times 10^6) = 1.7 \times 10^{-6} \text{ rad s}^{-1}$ ✓ (1.65×10^{-6}) leading to $\omega_2 = 20 \text{ rad s}^{-1}$ [19.3 if 1.65×10^{-6} used] $T_2 = 2\pi/\omega_2 = 0.31 \text{ s}$ (2 sf throughout) ✓ 2 sf ✓ [0.33 s if $1.65 \times 10^{-6} \text{ rad s}^{-1}$ and 19.3 rad s^{-1} used]	4
	Total	7

Question 2		
a	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate provides a comprehensive and logical explanation which recognises that energy stored depends on moment of inertia and ω^2 and that moment of inertia itself depends on the mass and how the mass is distributed about the axis of rotation, quoting and explaining Σmr^2. They will appreciate that a high mass will result from using high density material and they will realise that increasing the radius alone will not necessarily increase M of I for a given mass, but the shape (eg spoked or not) might. They will refer to means of promoting high speed and may appreciate why there is a limit to the maximum speed depending on tensile strength. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate provides a comprehensive and logical explanation which links moment of inertia and ω^2 to energy stored and will discuss the factors that affect the moment of inertia, but there may be errors in their understanding. They will probably refer to the need to reduce friction but they may not state how this may be done. There may be some reference to the density or strength of the materials used, but the links with energy storage or M of I will be vague. The answer should be adequately or well-presented in terms of spelling, punctuation and grammar. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate recognises that energy storage depends on speed and M of I, but may not link M of I adequately to radius or mass or the distribution of the mass. They may confuse power or angular momentum with energy. The answer may lack coherence and may contain a significant number of errors in terms of spelling and punctuation. Incorrect, inappropriate or no response: 0 marks No answer or answer refers to unrelated, incorrect or inappropriate physics.	max 6

		Statements expected in a competent answer should include some of the following marking points. Linking E to ω^2 Linking E to Σmr^2 Importance of shape; put more m at greater r, use thin axle High density material promotes high m for given size Friction reduced by low-friction (eg magnetic- or air-) bearings and smooth outer surface Rotational speed limited by tensile strength of material Reference to centripetal force Frictional torque increases with rotational speed Some answers might refer to adverse gyroscopic effects or need for perfect balance	
b	i	$\Delta E = \frac{1}{2} I (\omega_1^2 - \omega_2^2) = 0.5 \times 0.036 \times (6400^2 - 3100^2) = 560 \times 10^3 \text{ J} \checkmark$	1
b	ii	$P = E/t = \frac{560 \times 10^3}{6.6} = 85000 \text{ W} \checkmark$ accept 85 kW if unit is changed in answer line from W to kW	1
b	iii	$T = P/\omega_{\text{ave}} = \frac{85 \times 10^3}{4750} \checkmark \text{ N m} \checkmark$ or $T = I \alpha = 0.036 \times \frac{(6400 - 3100)}{6.6} = 18 \checkmark \text{ N m} \checkmark$	2
b	iv	$T\theta = \Delta E$ $\theta = 560 \times 10^3 / 18 = 31 \times 10^3 \text{ rad} \checkmark$ $\frac{31 \times 10^3}{2\pi} = 4900 \text{ rev} \checkmark$ or $\theta = \frac{1}{2} (6400 + 3100) \times 6.6 = 31 \times 10^3 \text{ rad} \checkmark$ $= 4900 \text{ rev} \checkmark$ or $\theta = \omega_1 t - \frac{1}{2} \alpha t^2$ $= 6400 \times 6.6 - \frac{1}{2} 500 \times 6.6^2 = 31 \times 10^3 \text{ rad} \checkmark$ $= 4900 \text{ rev} \checkmark$	2
		Total	12

Question 3		
a	i	use of $PV/T = \text{constant}$ $\frac{P_D V_D T_A}{P_A V_A} \checkmark$ $= \frac{2.5 \times 1.0 \times 300}{1.5 \times 1.0} \checkmark = 500 \text{ K}$
a	ii	$Q = \Delta U + W$ $\Delta U = 0 \checkmark$ $Q = W = 173 \text{ J} \checkmark$
b	i	work out = $173 - 104 = 69 \text{ J} \checkmark$
b	ii	efficiency = $69/173 = 0.40$ or $40\% \checkmark$ $\eta_{\text{max}} = (T_H - T_C)/T_H$ $= (500 - 300)/500$ $= 0.39 \text{ or } 40\% \checkmark$
c		 rectangle in correct position $\checkmark$ letters correct place $\checkmark$ (arrows optional)
d		- isothermal process impossible unless very slow or via perfect conductor - engine would have to stop for constant volume processes to take place - regenerator would lose heat to surroundings (unless perfectly insulated) - long time needed for heat to transfer from regenerator to working fluid - regenerator would need to be very large/large surface area for heat transfer to take place quickly accept other sensible suggestions do not accept 'heat loss to surroundings' or 'friction' any two $\checkmark\checkmark$
Total		11

Question 4		
a	i	$3.2 \times 780 = 2500 \text{ W} \checkmark$
a	ii	$2500 - Q_{\text{out}} = 780$ $Q_{\text{out}} = 1720 \text{ W} \checkmark$ or $3.2 = \frac{Q_{\text{in}}}{Q_{\text{in}} - Q_{\text{out}}} = \frac{2500}{2500 - Q_{\text{out}}}$ giving $Q_{\text{out}} = 1720 \text{ W} \checkmark$
b		- heat pump does deliver more energy than is input as work on the system but there must also be energy input from cold space $\checkmark$ - obeys conservation of energy because work done plus energy from cold space (or equivalent, eg ground) equals energy by heat transfer to hot space (or equivalent) $\checkmark$ - obeys second law because (reversed heat engine) operates between hot and cold spaces [accept 'source' and 'sink'] $\checkmark$ - work done on the system requires energy transfer (from a heat engine elsewhere) so overall result is spreading out of energy [owtte] $\checkmark$
		Total
		5
		UMS conversion calculator www.aqa.org.uk/umsconversion

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										



General Certificate of Education
Advanced Level Examination
June 2010

Physics A

PHYA5/2C

**Unit 5C Applied Physics
Section B**

Tuesday 29 June 2010 1.30 pm to 3.15 pm

For this paper you must have:

- a calculator
- a ruler
- a Data and Formulae Booklet.

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
TOTAL	



J U N 1 0 P H Y A 5 2 C 0 1

WMP/Jun10/PHYA5/2C

STEMUP.CO.UK

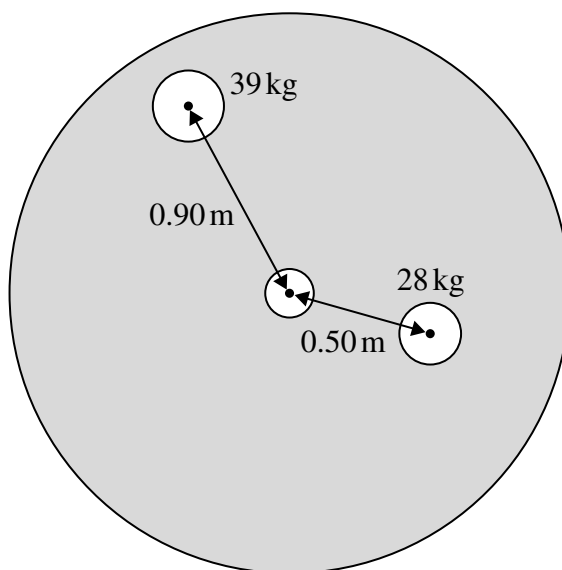
PHYA5/2C

Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** A playground roundabout has a moment of inertia about its vertical axis of rotation of 82 kg m^2 . Two children are standing on the roundabout which is rotating freely at 35 revolutions per minute. The children can be considered to be point masses of 39 kg and 28 kg and their distances from the centre are as shown in **Figure 1**.

Figure 1



- 1 (a) (i)** Calculate the total moment of inertia of the roundabout and children about the axis of rotation. Give your answer to an appropriate number of significant figures.

answer = ... kg m^2
(3 marks)

- 1 (a) (ii)** Calculate the total rotational kinetic energy of the roundabout and children.

answer = ... J
(2 marks)



1 (b) The children move closer to the centre of the roundabout so that they are both at a distance of 0.36 m from the centre. This changes the total moment of inertia to 91 kg m^2 .

1 (b) (i) Explain why the roundabout speeds up as the children move to the centre of the roundabout.

.....

.....

.....

.....

(2 marks)

1 (b) (ii) Calculate the new angular speed of the roundabout. You may assume that the frictional torque at the roundabout bearing is negligible.

answer = ... rad s^{-1}
(2 marks)

1 (b) (iii) Calculate the new rotational kinetic energy of the roundabout and children.

answer = ... J
(1 mark)

1 (c) Explain where the increase of rotational kinetic energy of the roundabout and children has come from.

.....

.....

.....

(1 mark)



- 2** A grinding wheel is used to sharpen chisels in a school workshop. A chisel is forced against the edge of the grinding wheel so that the tangential force on the wheel is a steady 7.0 N as the wheel rotates at 120 rad s^{-1} . The diameter of the grinding wheel is 0.15 m.

- 2 (a) (i)** Calculate the torque on the grinding wheel, giving an appropriate unit.

answer = ...
(2 marks)

- 2 (a) (ii)** Calculate the power required to keep the wheel rotating at 120 rad s^{-1} .

answer = ... W
(1 mark)

- 2 (b)** When the chisel is removed and the motor is switched off, it takes 6.2 s for the grinding wheel to come to rest.

Calculate the number of rotations the grinding wheel makes in this time.

answer = ...
(2 marks)



- 3 (a)** The coefficient of performance of a refrigerator is given by

$$COP_{\text{ref}} = \frac{Q_{\text{out}}}{Q_{\text{in}} - Q_{\text{out}}}$$

With reference to a refrigerator, explain the terms Q_{in} and Q_{out} .

.....

.....

.....

.....

(2 marks)

- 3 (b)** A refrigerator is designed to make ice at -10°C from water initially at room temperature. The energy needed to make 1.0 kg of ice at -10°C from water initially at room temperature is 420 kJ. The refrigerator has a coefficient of performance of 4.5.
- 3 (b) (i)** Calculate the power input to the refrigerator if it is required to make 5.5 kg of ice every hour.

answer = ... W
(2 marks)

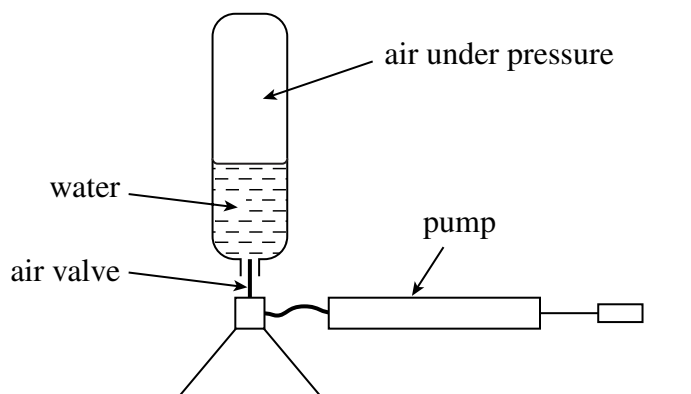
- 3 (b) (ii)** Calculate the rate at which energy is delivered to the surroundings of the refrigerator.

answer = ... W
(1 mark)

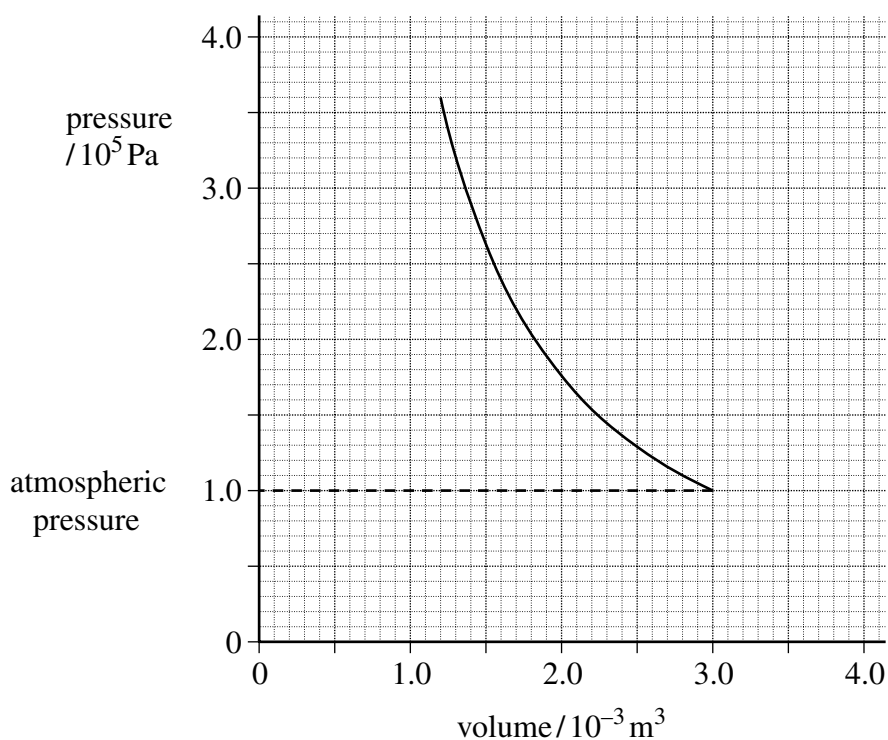


- 4 **Figure 2** shows a model rocket for demonstrating the principle of rocket propulsion. Air is pumped into an upside-down plastic bottle that has been partly filled with water. When the pressure reaches $3.6 \times 10^5 \text{ Pa}$, (i.e. $2.6 \times 10^5 \text{ Pa}$ above atmospheric pressure) the air valve is forced out by the water pressure and the air in the bottle expands. The expanding air forces the water out of the neck of the bottle at high speed; this provides the thrust that lifts the bottle high into the air.

Figure 2



The graph shows the variation of pressure with volume for the air initially in the bottle as it expands from $3.6 \times 10^5 \text{ Pa}$ to atmospheric pressure, assuming the expansion is adiabatic.



- 4 (a)** Use the graph to estimate the work done by the air as it expands from a pressure of $3.6 \times 10^5 \text{ Pa}$ to atmospheric pressure.

answer = ... J
(3 marks)

- 4 (b)** With reference to the graph on **page 6**, state and explain whether the rocket would have reached the same height if the air had expanded isothermally.

.....

.....

.....

.....

.....

(3 marks)

6

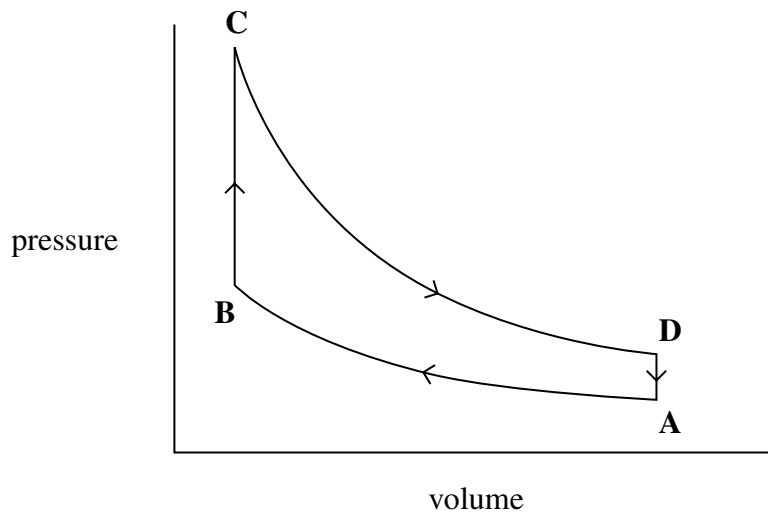
Turn over for the next question

Turn over ►



- 5 (a) **Figure 3** shows the indicator diagram for a theoretical or ideal four-stroke petrol engine (Otto) cycle.

Figure 3



Use **Figure 3** to describe the process that occurs during each of the parts **A to B**, **B to C**, **C to D** and **D to A** of the cycle. Describe whether heating or cooling is taking place, the type of process and whether work is being done on or by the air.

The quality of your written answer will be assessed in this question.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



.....

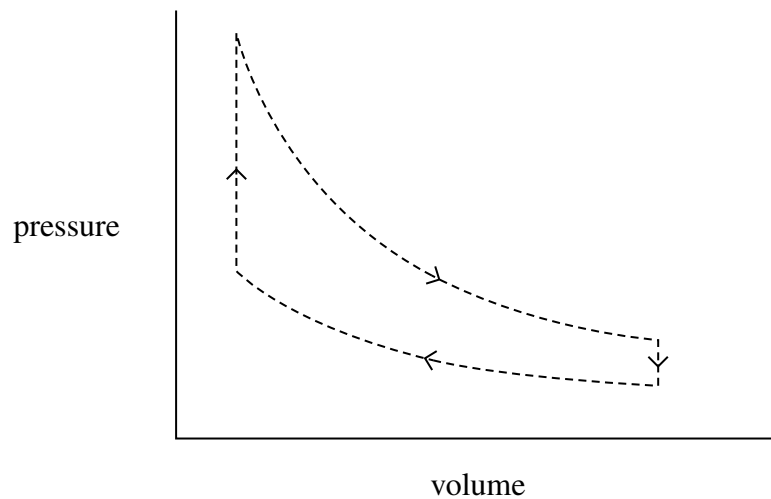
.....

.....

.....

(6 marks)

- 5 (b)** Show, on **Figure 4**, how the indicator diagram might be expected to appear if measurements of pressure and volume were made on a real four-stroke petrol engine of the same volume under operating conditions. The ideal cycle is shown in dashed lines as a guide.

Figure 4

(2 marks)

8

END OF QUESTIONS

There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**



There are no questions printed on this page

**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

Copyright © 2010 AQA and its licensors. All rights reserved.





**General Certificate of Education
June 2010**

Physics A

PHYA5/2C

Applied Physics

Unit 5

Final

Mark Scheme

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.

Further copies of this Mark Scheme are available to download from the AQA Website: www.aqa.org.uk

Copyright © 2010 AQA and its licensors. All rights reserved.

COPYRIGHT

AQA retains the copyright on all its publications. However, registered centres for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to centres to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Set and published by the Assessment and Qualifications Alliance.

Instructions to Examiners

- 1 Give due credit for alternative treatments which are correct. Give marks for what is correct in accordance with the mark scheme; 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 scripts to the Awards meeting if poor presentation forbids a proper assessment. In each paper, candidates are assessed on their quality of written communication (QWC) in designated questions (or part-questions) that require explanations or descriptions. The criteria for the award of marks on each such question are set out in the mark scheme in three bands in the following format. The descriptor for each band sets out the expected level of the quality of written communication of physics for each band. Such quality covers the scope (eg relevance, correctness), sequence and presentation of the answer. Amplification of the level of physics expected in a good answer is set out in the last row of the table. To arrive at the mark for a candidate, their work should first be assessed holistically (ie in terms of scope, sequence and presentation) to determine which band is appropriate then in terms of the degree to which the candidate's work meets the expected level for the band.

QWC	descriptor	mark range
Good - Excellent	<i>see specific mark scheme</i>	5-6
Modest - Adequate	<i>see specific mark scheme</i>	3-4
Poor - Limited	<i>see specific mark scheme</i>	1-2
The description and/or explanation expected in a good answer should include a coherent account of the following points: <i>see specific mark scheme</i>		

Answers given as bullet points should be considered in the above terms. Such answers without an 'overview' paragraph in the answer would be unlikely to score in the top band.

- 3 An arithmetical error in an answer will cause the candidate to lose one mark and should be annotated AE if possible. 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.
- 4 The use of significant figures is tested **once** on each paper in a designated question or part-question. The numerical answer on the designated question should be given to the same number of significant figures as there are in the data given in the question or to one more than this number. All other numerical answers should not be considered in terms of significant figures.
- 5 Numerical answers **presented** in non-standard form are undesirable but should not be penalised. Arithmetical errors by candidates resulting from use of non-standard form in a candidate's working should be penalised as in point 3 above. Incorrect numerical prefixes and the use of a given diameter in a geometrical formula as the radius should be treated as arithmetical errors.
- 6 Knowledge of units is tested on designated questions or parts of questions in each a paper. On each such question or part-question, unless otherwise stated in the mark scheme, the mark scheme will show a mark to be awarded for the numerical value of the answer and a further mark for the correct unit. No penalties are imposed for incorrect or omitted units at intermediate stages in a calculation or at the final stage of a non-designated 'unit' question.
- 7 All other procedures including recording of marks and dealing with missing parts of answers will be clarified in the standardising procedures.

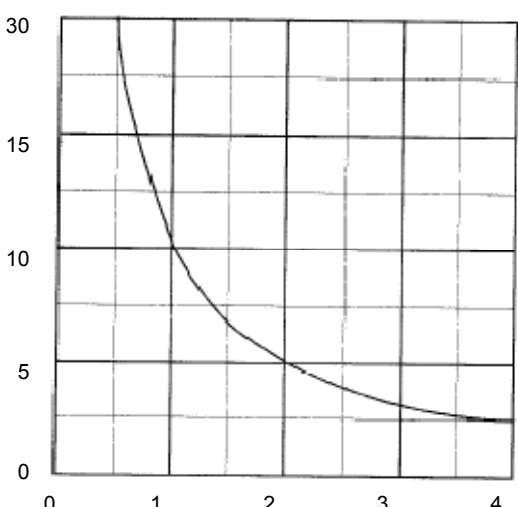
GCE Physics, Specification A, PHYA5/2C, Section A, Nuclear and Thermal Physics

Question 1		
(a)	using $Q = mc\Delta\theta$ $= 3.00 \times 440 \times (84-27) \checkmark$ $7.5 \times 10^4 \text{ (J)} \checkmark$	2
(b)	using $Q = ml$ $= 1.20 \times 2.5 \times 10^4$ $= 3.0 \times 10^4 \text{ (J)} \checkmark$	1
(c)	(heat supplied by lead changing state + heat supplied by cooling lead = heat gained by iron) $3.0 \times 10^4 + \text{heat supplied by cooling lead} = 7.5 \times 10^4 \checkmark$ heat supplied by cooling lead $= 4.5 \times 10^4 = mc\Delta\theta$ $c = 4.5 \times 10^4 / (1.2 \times (327 - 84)) \checkmark$ $c = 154 \text{ (J kg}^{-1} \text{ K}^{-1}) \checkmark$	3
(d)	any one idea $\checkmark$ no allowance has been made for heat loss to the surroundings or the specific heats may not be a constant over the range of temperatures calculated	1
	Total	7

Question 2		
(a)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate can explain the role of the moderator and control rods in maintaining a critical condition inside the reactor. The explanation is given in a clear sequence of events and the critical condition is defined in terms of neutrons. To obtain the top mark some other detail must be included. Such as, one of the alternative scattering or absorbing possibilities or appropriate reference to critical mass or detailed description of the feedback to adjust the position of the control rods etc. Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate has a clear idea of two of the following: the role of the moderator, the role of the control rods or can explain the critical condition. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate explains that a released neutron is absorbed by uranium to cause a further fission. Alternatively the candidate may explain one of the following: the role of the moderator, the role of the control rods or can explain the critical condition. The explanation expected could include the following events that could happen to a released neutron. a neutron is slowed by the moderator taking about 50 collisions to reach thermal speeds then absorbed by uranium-235 to cause a fission event one neutron released goes on to cause a further fission is the critical condition a neutron may leave the reactor core without further interaction a neutron could be absorbed by uranium-238 a neutron could be absorbed by a control rod a neutron could be scattered by uranium-238 a neutron could be scattered by uranium-235	max 6

(b)	it is easy to stay out of range or easy to contain an α source or β/γ have greater range/are more difficult to screen ✓ most (fission fragments) are (more) radioactive/unstable ✓ and are initially most likely to be beta emitters/(which also) emit γ radiation/are neutron rich/heavy ✓ ionising radiation damages body tissue/is harmful ✓	max 3
	Total	9

Question 3		
(a)	probability of decay per unit time/given time period or fraction of atoms decaying per second or the rate of radioactive decay is proportional to the number of (unstable) nuclei and nuclear decay constant is the constant of proportionality ✓	1
(b)	use of $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ $T_{\frac{1}{2}} = \ln 2 / 3.84 \times 10^{-12} \text{ s} \checkmark (1.805 \times 10^{11} \text{ s})$ $= (1.805 \times 10^{11} / 3.15 \times 10^7) = 5730 \text{ y} \checkmark$ answer given to 3 sf ✓	3
(c)	number of nuclei = $N = 3.00 \times 10^{23} \times 1/10^{12} \checkmark$ $(= 3.00 \times 10^{11} \text{ nuclei})$ (using $\frac{\Delta N}{\Delta t} = -\lambda N$) rate of decay = $3.84 \times 10^{-12} \times 3.00 \times 10^{11} \checkmark$ $(= 1.15 \text{ Bq})$	2
(d)	$(N = N_0 e^{-\lambda t}$ and activity is proportional to the number of nuclei $A \propto N$ use of $A = A_0 e^{-\lambda t}$) $0.65 = 1.15 \times e^{-3.84 \times 10^{-12} t} \checkmark$ $t = \frac{\ln(\frac{1.15}{0.65})}{3.84 \times 10^{-12}}$ or $\frac{\ln(\frac{0.651}{1.15})}{-3.84 \times 10^{-12}} \checkmark$ $t = 4720 \text{ y} \checkmark$	3
(e)	the boat may have been made with the wood some time after the tree was cut down the background activity is high compared to the observed count rates the count rates are low or sample size/mass is small or there is statistical variation in the recorded results possible contamination uncertainty in the ratio of carbon-14 in carbon thousands of years ago any two ✓✓	2
	Total	11

Question 4														
(a)	pressure/10^4 Pa  curve with decreasing negative gradient that passes through the given point which does not touch the x axis ✓ <table border="1" data-bbox="410 949 873 1270"><thead><tr><th colspan="2">designated points</th></tr><tr><th>pressure/10^4 Pa</th><th>volume/10^{-3} m³</th></tr></thead><tbody><tr><td>10</td><td>1.0</td></tr><tr><td>5.0</td><td>2.0</td></tr><tr><td>4.0</td><td>2.5</td></tr><tr><td>2.5</td><td>4.0</td></tr></tbody></table> 2 of the designated points ✓✓ (one mark each)	designated points		pressure/ 10^4 Pa	volume/ 10^{-3} m ³	10	1.0	5.0	2.0	4.0	2.5	2.5	4.0	3
designated points														
pressure/ 10^4 Pa	volume/ 10^{-3} m ³													
10	1.0													
5.0	2.0													
4.0	2.5													
2.5	4.0													
(b) (i)	$N = PV/kT = 5 \times 10^4 \times 2 \times 10^{-3} / 1.38 \times 10^{-23} \times 290$ ✓ [or alternative use of $PV = nRT$ $5 \times 10^4 \times 2.0 \times 10^{-3} / 8.31 \times 290 = 0.0415$ moles] $= 2.50 \times 10^{22}$ molecules ✓	2												
(b) (ii)	(mean) kinetic energy of a molecule $= \frac{3}{2}kT = \frac{3}{2} \times 1.38 \times 10^{-23} \times 290$ ✓ ($= 6.00 \times 10^{-21}$ J) (total kinetic energy = mean kinetic energy $\times N$) $= 6.00 \times 10^{-21} \times 2.50 \times 10^{22}$ ✓ $= 150$ (J) ✓	3												

(c)	all molecules/atoms are identical molecules/atoms are in random motion Newtonian mechanics apply gas contains a large number of molecules the volume of gas molecules is negligible (compared to the volume occupied by the gas) or reference to point masses no force act between molecules except during collisions or the speed/velocity is constant between collisions or motion is in a straight line between collisions collisions are elastic or kinetic energy is conserved and of negligible duration any 4 ✓✓✓✓	max 4
	Total	12

GCE Physics, Specification A, PHYA5/2C, Section B, Applied Physics

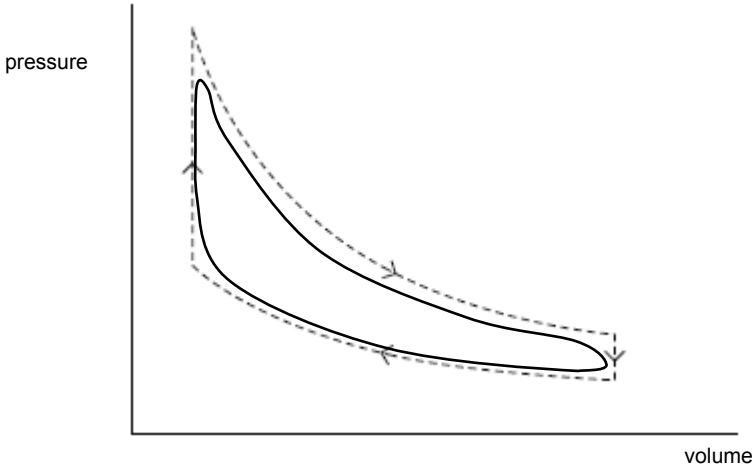
Question 1		
(a) (i)	$I = 82 + 39 \times 0.90^2 + 28 \times 0.50^2 \checkmark$ $= 120 \text{ kg m}^2 \checkmark$ to 2 sig figs $\checkmark$	3
(a) (ii)	$\omega = 35 \times 2\pi/60 \checkmark = 3.7 \text{ rad s}^{-1}$ $E = \frac{1}{2}I\omega^2 = 0.5 \times 120 \times 3.7^2 = 820 \text{ J} \checkmark$ (accept 800 to 821 J depending on sf carried through)	2
(b) (i)	angular momentum must be conserved $\checkmark$ so if I decreases ω must increase $\checkmark$	2
(b) (ii)	$120 \times 3.7 = 91 \times \omega_2 \checkmark$ $\omega_2 = 4.9 \text{ rad s}^{-1} \checkmark$	2
(b) (iii)	$E = 0.5 \times 91 \times 4.9^2 = 1100 \text{ J (1090 J)} \checkmark$ (give CE only if correct I value used) accept 1050 – 1100 J	1
(c)	work done or energy transferred as children move towards the centre $\checkmark$ or work done as centripetal force moves inwards $\checkmark$	1
Total		11

Question 2		
(a) (i)	$T = Fr = 7.0 \times 0.075$ $= 0.53 \checkmark \text{ N m} \checkmark$	2
(a) (ii)	$P = T\omega$ $= 0.53 \times 120 = 64 \text{ W} \checkmark$	1
(b)	use of equation(s) of motion: $\theta = \frac{1}{2}(120 + 0) \times 6.2 = 370 \text{ rad} \checkmark$ $370/2\pi = 59 \text{ rotations} \checkmark$	2
Total		5

Question 3		
(a)	(refrigerator operates between a cold space and a hot space) Q_{out} is the energy removed from the fridge contents (or from the cold space) ✓ Q_{in} is the energy given to the surroundings (or to outside the fridge/hot space) ✓	2
(b) (i)	power for cooling ice = $5.5 \times (420 \times 10^3)/3600 = 642 \text{ W}$ ✓ $P_{\text{in}} = 642/4.5 = 142 \text{ W}$ ✓ or energy taken from ice in 1 hour = $5.5 \times 420 \times 10^3 = 2310 \text{ kJ}$ $W_{\text{in}} = 2310/4.5 = 513 \text{ kJ}$ ✓ $P_{\text{in}} = \frac{(513 \times 10^3)}{3600} = 142 \text{ W}$ ✓	2
(b) (ii)	$Q \text{ per s} = 142 + 642$ $= 784 \text{ W}$ (give CE) ✓ or $Q_{\text{in}} = Q_{\text{out}} + W_{\text{in}} = 513 \text{ kJ} + 2310 \text{ kJ} = 2820 \text{ kJ}$ $Q_{\text{in}} \text{ per s} = \frac{2820 \times 10^3}{3600} = 784 \text{ W}$ ✓	1
Total		5

Question 4		
(a)	work done = area under line ✓ appropriate method for finding area eg counting squares ✓ correct scaling factor used (to give answer of $150 \text{ J} \pm 10 \text{ J}$) ✓ if candidate correctly calculates area under curve to a pressure of zero Pa, ($330 \text{ J} \pm 20 \text{ J}$) award 2 marks	3
(b)	if isothermal line would have been less steep ✓ (so greater area under line and) more work done ✓ so rocket would rise higher ✓	3
Total		6

Question 5		
(a)	The candidate's writing should be legible and the spelling, punctuation and grammar should be sufficiently accurate for the meaning to be clear. The candidate's answer will be assessed holistically. The answer will be assigned to one of three levels according to the following criteria. High Level (Good to excellent): 5 or 6 marks The information conveyed by the answer is clearly organised, logical and coherent, using appropriate specialist vocabulary correctly. The form and style of writing is appropriate to answer the question. The candidate correctly identifies the two adiabatic and two constant volume processes described in their correct sequence and gives detailed consideration of where heating, cooling and work transfers take place. The candidate states that work is done on the gas only in $A \rightarrow B$ and by the gas only in $C \rightarrow D$, and/or states that the area of the loop is net work done. There is also some reference to temperatures and pressures increasing or decreasing Intermediate Level (Modest to adequate): 3 or 4 marks The information conveyed by the answer may be less well organised and not fully coherent. There is less use of specialist vocabulary, or specialist vocabulary may be used incorrectly. The form and style of writing is less appropriate. The candidate correctly identifies where some of the heat and work transfers take place but the answer is much more limited. The adiabatic processes may not be named as such, but there is a statement that work is done in these processes or that there is no heat transfer. One process might be missed out altogether or be incorrect. There may be reference to temperatures, volumes and pressures increasing or decreasing. Low Level (Poor to limited): 1 or 2 marks The information conveyed by the answer is poorly organised and may not be relevant or coherent. There is little correct use of specialist vocabulary. The form and style of writing may be only partly appropriate. The candidate may refer (incorrectly) to the four processes as making up the four strokes of the engine real engine and some credit may be given if there is a statement that $A \rightarrow B$ is the compression stroke and $C \rightarrow D$ is the power stroke. The answer may be written mainly in terms of pressures, volumes and temperatures increasing or decreasing with little reference to the type of process or heat or work transfers. The candidate may relate the answer to a real engine rather than the theoretical cycle eg 'the spark occurs at B'.	max 6

	The explanation expected in a competent answer should include a coherent selection of the following points concerning the physical principles involved and their consequences in this case. A to B work done on air adiabatic compression no heat transfer (from air) temperature rises B to C no work done heating at constant volume temperature rises (and also pressure) C to D work done by air <i>accept power stroke</i> adiabatic expansion no heat transfer (to air) work done at expense of kinetic energy of molecules D to A cooling (or heat rejected) at constant volume with no work done temperature falls accept answers which cover above points and include reference to piston, cylinder, valves	
(b)	 induction and exhaust 'pumping' loop shown ✓ loop of smaller area than ideal loop with 'rounded' corners ✓	2
	Total	8