OCR ADVANCED SUBSIDIARY GCE IN PHYSICS A (3883)

OCR ADVANCED GCE IN PHYSICS A (7883)

Specimen Question Papers and Mark Schemes

These specimen assessment materials are designed to accompany the OCR Advanced Subsidiary GCE and Advanced GCE specifications in Physics A for teaching from September 2000.

Centres are permitted to copy material from this booklet for their own internal use.

The GCE awarding bodies have prepared new specifications to incorporate the range of features required by new GCE and subject criteria. The specimen assessment material accompanying the new specifications is provided to give centres a reasonable idea of the general shape and character of the planned question papers in advance of the first operational examination.

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Physics A

FORCES AND MOTION **2821**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Answer all the questions in the space provided.

Answer **all** the questions in the spaces provided.

1 **(a)** State the important difference between a vector and a scalar.

.... **[1]**

(b) Put the following quantities into a list of vectors and a list of scalars.

MASS FORCE SPEED VELOCITY WORK DISPLACEMENT

vectors scalars

[3]

(c) In order to display greeting cards, a student fixes a length of string between two nails and then suspends the cards from the string. Fig. 1.1 shows the string with one card of weight 0.60 N suspended by a light clip at the centre of the string.

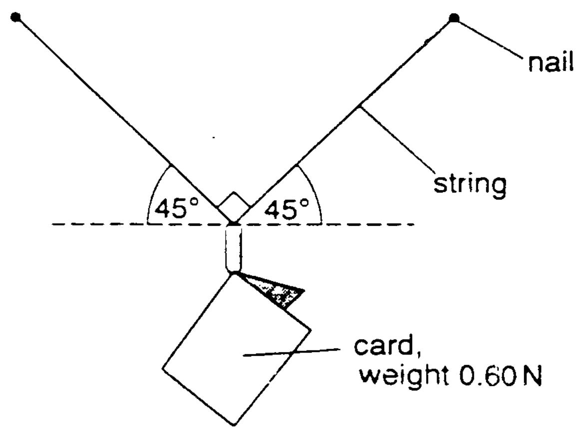


Fig. 1.1

(i) On Fig. 1.1, mark the forces on the clip due to the tension in the string. **[2]**

(ii) The resultant of the forces due to the tension in the string is 0.60 N. In the space below, draw a vector triangle for the forces in the string and their resultant. Use a scale of 1.0 cm to represent 0.10 N. **[3]**

(iii) Use your completed vector diagram to determine the magnitude of the tension in the string.

tension = ...N **[1]**

(d) The student decides that she would like as little sag as possible in the string when it is loaded with cards. To achieve this, she tightens the string. State, with a reason, whether the string, loaded with cards, could ever be horizontal.

....

....

....

.... **[2]**

2 **(a)** **(i)** Define acceleration.

....

.... **[2]**

(ii) State the unit for acceleration.

.... **[3]**

(b) Fig. 2.1 shows the variation with time t of velocity v for a short journey travelled by a car of mass 800 kg.

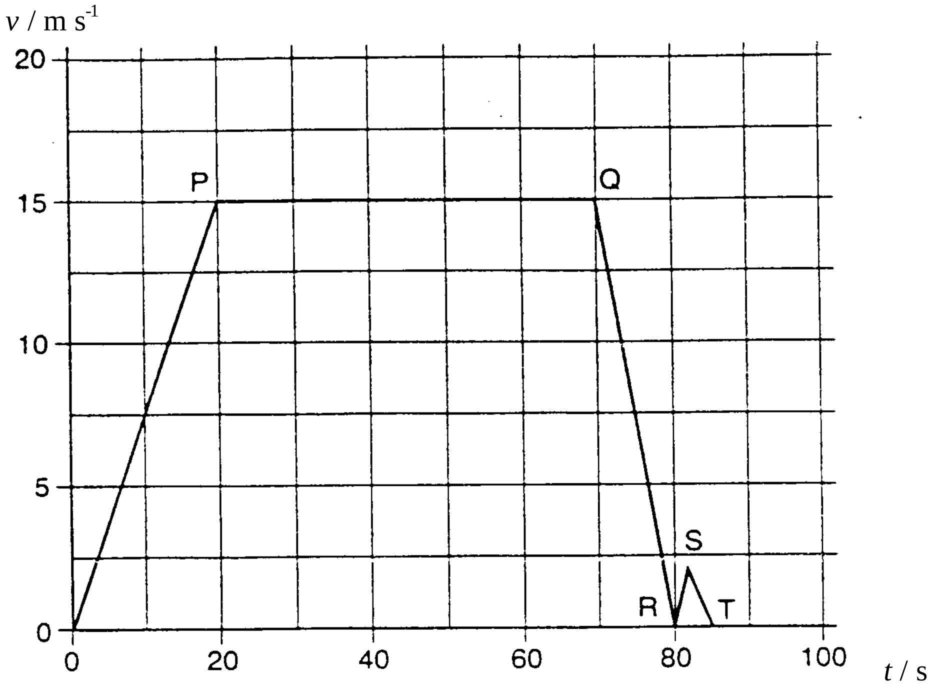


Fig. 2.1

Calculate

(i) the acceleration of the car during the first 20s of the journey,

acceleration = ...

[2]

(ii) the resultant force that acted on the car during this 20 s interval,

force = ...N **[2]**

(iii) the distance travelled by the car during the first 80 s of the journey.

distance = ...m **[4]**

(c) On Fig. 2.1, RT indicates an interval of time during which the car was involved in a minor traffic accident. Suggest, with a reason, a likely nature of the accident.

....

....

.... **[2]**

3 A sky-diver jumps from an aircraft at altitude 4000m and delays opening his parachute until he reaches altitude 1000m.
In this question, consider only vertical velocity.

(a) During the first 3.0 s after leaving the aircraft, air resistance to his fall can be neglected.

Calculate, for the first 3.0 s

(i) the vertical downward velocity he will achieve,

....

....

....

velocity = …………………m s^{-1} **[2]**

(ii) the vertical distance he travels.

....

....

distance = ………………….m **[2]**

(b) Describe qualitatively how his velocity will change during the rest of the time he is falling, but before the parachute is opened. Explain why his velocity changes in the way you have described.

…………………………………………………………………….…………………

……………………………………………..……………………………………

…………………………………………..………………………………………

……………………………………………….…………………………………

………………………………………………….………………………………

…………………………………………………………...……………………... **[5]**

(c) When he opens his parachute at 1000 m, he is travelling downwards with a velocity of 60 m s-1.
On Fig. 3.1, draw two labelled sketch graphs on the same time-axis to show qualitatively the variation with time of

(i) the parachutist's velocity as it is reduced to 5 m s^{-1} for landing, **[3]**

(ii) the force which the parachute exerts on the parachutist. **[3]**

t

Fig 3.1

4 An astronaut measures his mass and his weight when he is standing on the surface of the Earth and when he is standing on the Moon. He finds that his mass has not changed but his weight is much less on the Moon than on the Earth.

(a) State what is meant by

(i) the mass of the body,

....

.... **[1]**

(ii) the weight of the body.

....

....
[1]

(b) Give the SI units for mass and weight.

unit of mass

....

....

unit of weight

.... **[1]**

(c) Put in words the equation which connects weight and mass.

....

.... **[2]**

(d) Suggest why the astronaut's weight is different on Earth and on the Moon.

....

.... **[2]**

5 **(a)** **(i)** Define the moment of a force. Illustrate your answer with a diagram.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… **[2]**

(ii) Define torque of a couple.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… **[2]**

(b) An electricity cable is attached to a pole at a height of 6.0 m above the ground as shown in Fig. 5.1.

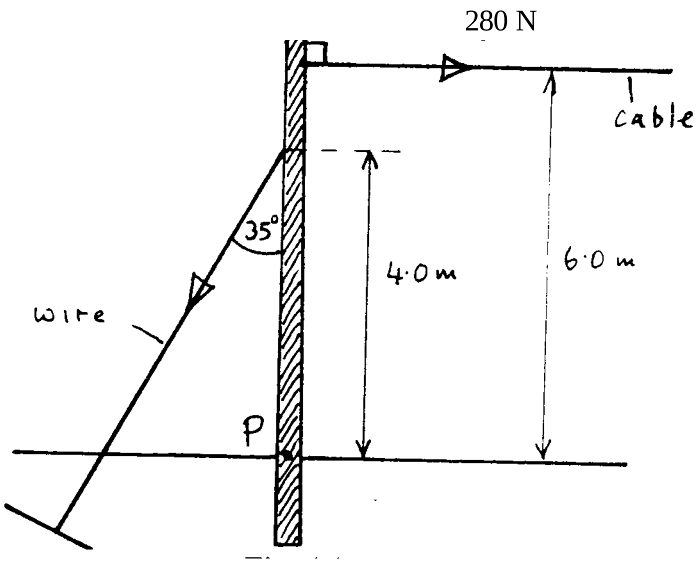


Fig. 5.1

The cable exerts a force of 280 N on the pole at an angle of 90° to the pole. So that there is zero turning moment on the pole itself, a wire under tension is attached to the pole at a height of 4.0 m and it makes an angle of 35° to the pole.

Calculate

(i) the moment which the cable exerts about P, a point in the pole level with the ground.

moment = ...N m **[2]**

(ii) the tension necessary in the wire.

tension = ...N**[3]**

6 A metal wire of length l and area of cross-section A is fixed at one end and hangs vertically with a load W attached to its free end. The wire is found to stretch by an amount Δx.

(a) Give, in terms of l, W and Δx, expressions, one in each case, for

(i) stress,

.... **[1]**

(ii) strain,

.... **[1]**

(iii) the Young modulus of the metal.

....

.... **[2]**

(b) The wire has length 2.5 m. A tensile stress of 6.4×10^7 Pa is applied. The Young modulus of the metal is 1.1 x 1011 Pa. For the wire, calculate

(i) the strain,

strain = ... **[2]**

(ii) the extension.

extension = ... m **[2]**

(c) Suggest, with a reason,

(i) whether a 30 cm rule would be a suitable measuring instrument for the extension.

....

.... **[2]**

(ii) what would happen to the extension if the wire were to be replaced by another wire of the same dimensions made of a metal with a smaller Young modulus. Assume that the load remains the same and that the wire does not exceed its elastic limit.

....

.... **[2]**

7 **(a)** Describe, using a diagram, how driving wheels can generate a motive force.

....

....

....

....

....

....

....

....

.... **[4]**

(b) State three factors which affect the maximum motive force which can be exerted on a particular car.

1 ....

2 ....

3 .... **[3]**

(c) A car is using a constant motive force of 850 N when travelling at a constant speed of 35 m s^{-1} along a motorway. Calculate the motive power which the engine is supplying.

motive power = ... W **[2]**

(d) The car in (c) does work of 5.5×10^5 J against a stopping force before coming to rest.

(i) Under normal conditions the stopping force (assumed constant) is 1200 N. Calculate the distance travelled after the stopping force is applied under normal conditions.

distance = ...m **[2]**

(ii) In icy conditions the stopping force is only 300 N. Calculate the new distance travelled before stopping.

distance = ... m **[1]**

(iii) Calculate the (assumed constant) force exerted on the car to stop it if, in an accident, it stops in a distance of 12 m.

force = ... N **[2]**

(e) Making reference to your answers to (d), describe how crumple zones help to reduce car accident injuries.

....

....

....

....

....

[4]

Quality of Written Communication
[4]

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

Physics A

FORCES AND MOTION **2821**

Mark Scheme

1	**(a)**	vector has direction, scalar does not		B1	**[1]**
	(b)	<u>vectors</u> — <u>scalars</u> force — mass velocity — speed displacement — work *minus one mark for each error or omission*		B3	**[3]**
	(c)	**(i)** Force shown correctly on card		B1	
		in both threads		B1	
		(ii) triangle: correct shape		B1	
		scale used correctly		B1	
		correct direction		B1	
		(iii) tension = 0.42 (allow ± 0.02 N)		B1	**[6]**
	(d)	not possible		M0	
		when string is horizontal, no vertical component		A1	
		to equal weight of card		A1	**[2]**
2	**(a)**	**(i)** acceleration as a rate of change of velocity with time *(allow 1 mark for speed)*		B2	
		(ii) metre second^{-2}		B1	**[3]**
	(b)	**(i)** acceleration given by gradient		C1	
		acceleration = 0.75 m s^{-2}		A1	
		(ii) $F = ma$		C1	
		= 800 x 0.75 = 600 N		A1	
		(iii) Finding area under graph		C1	
		lst section: ½ x 20 x 15 = 150 m		A1	
		2nd section: 15 x 50 = 750 m		A1	
		3rd section: ½ x 10 x 15 = 75 m			
		Total = 975 m		A1	**[8]**
	(c)	Car knocked forward		B1	
		so hit from behind		B1	**[2]**
3	**(a)**	**(i)** velocity = acceleration x time		C1	
		= 9.8 x 3 = 29.4 m s^{-1}		A1	**[2]**
		(ii) distance = average speed x time		C1	
		= 14.7 x 3 = 44 m		A1	**[2]**
	(b)	velocity will increase	(1)		
		so will air resistance	(1)		
		so acceleration will decrease	(1)		
		until it becomes zero	(1)		
		when air resistance equals weight	(1)		
		at which point there is terminal velocity	(1)		
		1 mark each point, max 5		B5	**[5]**
	(c)	velocity high at start	(1)		
		rapid decrease in velocity	(1)		
		velocity at low constant value	(1)		

		force zero at start	(1)		
		rising to high value	(1)		
		at maximum deceleration	(1)		
		force constant at end	(1)		
		1 mark each point, max 6		B6	**[6]**

4	**(a)**	mass in the property of a body which resists change in motion	B1	
		weight is the effect of a gravitational field on a mass	B1	**[2]**
	(b)	kilogram newton *(both correct)*	B1	**[1]**
	(c)	weight = mass x gravitational field strength OR = mass x acceleration of free fall (*allow 1 mark for weight = mass x g)*	B2	**[2]**
	(d)	Gravitational field strength is different on the Moon	C1	
		It is smaller on the Moon	A1	**[2]**

5	**(a)**	**(i)**	moment = force x perpendicular distance	B1	
			Arrangement shown on diagram	B1	
		(ii)	turning effect of couple, sum of moments	B1	
			One of the forces x perpendicular distance between them	B1	**[4]**
	(b)	**(i)**	moment = 280 x 6.0	C1	
			= 1680 N m	A1	
		(ii)	perpendicular distance = 4 sin 35		
			= 2.29(4) m	C1	
			∴ 1680 = T x 2.294	C1	
			T = 732 N	A1	**[5]**

6	**(a)**	**(i)**	$stress = W / A$	B1	
		(ii)	$strain = \Delta x / l$	B1	
		(iii)	$Y = stress / strain$	C1	
			$= Wl / A\Delta x$	A1	**[4]**
	(b)		$strain = stress / Y$		
			$= (6.4 \times 10^{7}) / (1.1 \times 10^{11})$	C1	
			$= 5.8 \times 10^{-4}$	A1	
			$extension = strain \times l$	C1	
			$= 5.8 \times 10^{-4} \times 2.5$		
			$= 1.45 \times 10^{-3}$ m	A1	**[4]**
	(c)	**(i)**	not suitable, distance too small	M1	
			graduation on rule too coarse for few mm of extension	A1	
		(ii)	extension greater	M1	
			same stress so strain must be larger	A1	**[4]**

7	**(a)**	Rotation driven from engine	B1	
		wheel pushes against ground	B1	
		Force forward equals force backward	B1	
		gives push of ground on wheel	B1	**[4]**
		Points may be scored in words or on diagram		
	(b)	e.g. maximum power of engine grip of tyre - i.e. tread road surface type snow/water present		
		any three relevant points, 1 each	B3	**[3]**
	(c)	*Power* = *force* x *velocity* C1 = 850 x 35		
		= 29750 W (30 kW)	A1	**[2]**
	(d)	**(i)** *Distance* = *work done* / *force*	C1	
		= $(5.5 \times 10^5) / 1200$ = 458 m	A1	
		(ii) New distance = $(5.5 \times 10^5) / 300$ = 1830 m	A1	
		(iii) Force = $(5.5 \times 10^5) / 12$	C1	
		= 46000 N	A1	**[5]**
	(e)	large forces exerted	B1	
		if distance to stop is small	B1	
		crumple zone allows a greater stopping distance	B1	
		so force on car / person is smaller	B1	**[4]**
		Quality of Written Communication	B4	**[4]**

FORCES AND MOTION

ASSESSMENT GRID

Question Number	Learning Outcome	Assessment Objective AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a)	1 (a)	1				1	
(b)	1 (a)	3				3	
(c) (i)	1 (b)	2				2	
(c) (ii)	1 (b)	2	1			3	
(c) (iii)	1 (b)	1				1	
(d)	1 (d)	2				2	12
2 (a) (i)	2 (a)	2				2	
(a) (ii)	2 (a)	1				1	
(b) (i)	2 (e)	2				2	
(b) (ii)	3 (b)	2				2	
(b) (iii)	2 (c) (g)	2	2			4	
(c)	2 (h)	2				2	13
3 (a)	2(g)	2	2			4	
(b)	2(h)	3	2			5	
(c)	2(e)(h)	3	3			6	15
4 (a) (i)	3 (a)	1				1	
(a) (ii)	3 (d)	1				1	
(b)	3 (a)	1				1	
(c)	3 (e)	2				2	
(d)	3 (d)	2				2	7
5 (a) (i)	4 (c)	2				2	
(a) (ii)	4 (b) (c)	2				2	
(b) (i)	4 (e)	1	1			2	
(b) (ii)	4 (d) (e)	2	1			3	9
6 (a) (i)	5 (c)	1				1	
(a) (ii)	5 (c)	1				1	
(a) (iii)	5 (c)	2				2	
(b)	5 (c)	1	3			4	
(c) (i)	5 (d)	1	1			2	
(c) (ii)	5 (g)		2			2	12

Question Number	Learning Outcome	Assessment Objective AO1	AO2	AO3	AO4	Section sub-total	Question total
7 (a)	6 (b)	3	1			4	
(b)	6 (a)	2	1			3	
(c)	6 (d)	1	1			2	
(d) (i)	7 (a), 4 (h) (i)	1	1			2	
(d) (ii)	7 (a), 4 (j)	1	1				
(d) (iii)	7 (a), 4 (j)	1	1			2	
(e)	7 (b) (d)	1	3			4	18
Quality of Written Communication		2	2			4	4
	totals	54	36			90	90

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

Physics A

ELECTRONS AND PHOTONS **2822**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Answer all the questions in the space provided.

1 **(a)** **(i)** Give, in words, the equation which is used to define charge.

……………………………………………………………………………………… **[1]**

(ii) State the SI unit of charge.

……………………………………………………………………………………… **[1]**

(iii) Define potential difference and its unit, the volt.

potential difference………………………………………………………………

………………………………………………………………………………………

volt……………………………………………………………………………… **[3]**

(b) In the circuit of Fig. 1.1, the 6.0 V d.c. supply has negligible internal resistance.

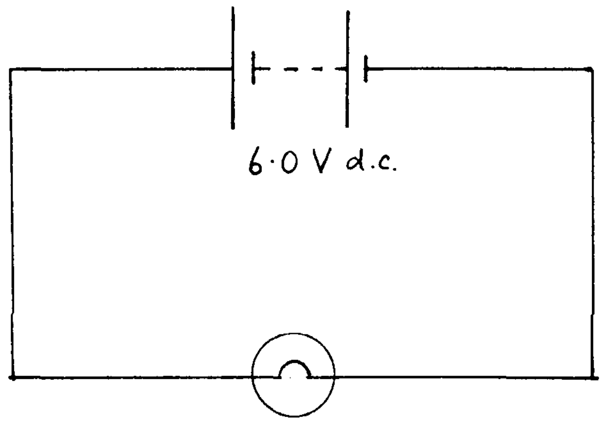


Fig. 1.1

(i) On Fig. 1.1, show, by means of arrows
1. the conventional current in the circuit (label this arrow C)
2. the electron flow in the circuit (label this arrow E). **[2]**

(ii) Calculate the energy transfer in the bulb when a charge of 15 C passes through it.

energy transfer = ………………………J **[2]**

(c) Fig. 1.2 shows a 12 V d.c. supply of negligible internal resistance connected to an arrangement of resistors.

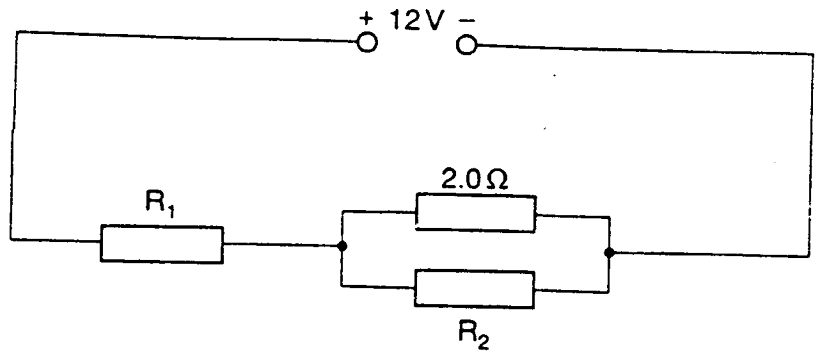


Fig. 1.2

The current in resistor R_1 is 5.0 A and the current in the resistor of resistance 2.0 Ω is 4.0 A.

Calculate

(i) the p.d. across the resistor of resistance 2.0 Ω ,

p.d. = ...V **[2]**

(ii) the resistance of resistor R_2 ,

resistance = ...Ω **[3]**

(iii) the p.d. across resistor R_1 ,

p.d. = …..V **[1]**

(iv) the resistance of resistor R_1.

resistance = ... W **[2]**

2 A radiant heater consists of four heating elements connected in parallel across a power supply as shown in Fig. 2.1.

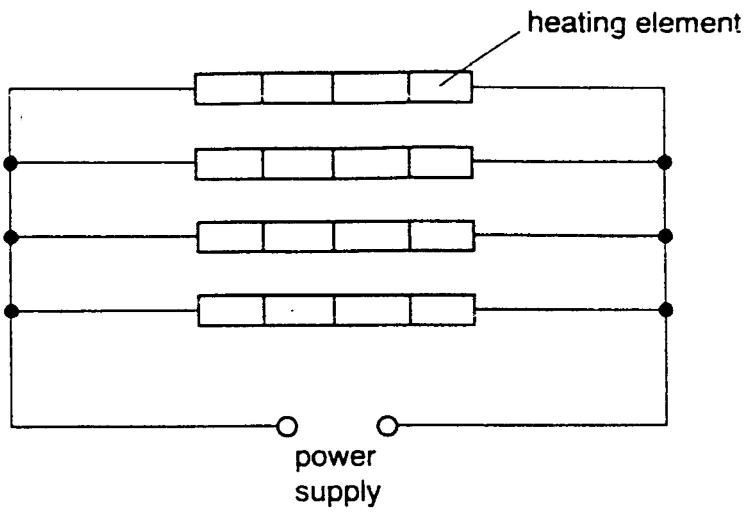


Fig. 2.1

Each heating element is made of wire of length 0.60 m and cross-sectional area 4.0×10^{-7} m^2. The wire has resistivity 8.0×10^{-5} Ω m at room temperature.

(a) **(i)** Show that the resistance of one heating element at room temperature is 120 Ω.

[3]

(ii) Calculate the total resistance at room temperature of the radiant heater.

resistance = ... Ω **[3]**

(iii) Calculate the power output from the radiant heater when it is connected to a 230 V supply.

power output = ... W **[3]**

(iv) Calculate the energy output of the heater in kWh if it is kept on for 8 hours.

energy = ...kWh **[2]**

(b) The wire in one of the elements of the radiant heater breaks. State and explain the effect on

(i) the total resistance of the heater,

....

....

....
. **[2]**

(ii) the power output of the heater.

....

....

....

....
[2]

(c) **(i)** On the axes of Fig. 2.2, sketch a typical current-voltage characteristic for a metallic heating element. **[2]**

Fig. 2.2

(ii) Explain the shape of your graph.

....

....

....

.... **[2]**

3 **(a)** State what is meant by

(i) the electromotive force (e.m.f.) of a battery,

....

....

.... **[2]**

(ii) the internal resistance of a battery.

....

....

[2]

(b) A student is asked to design a circuit to obtain potential differences of 4.0 V and 8.0 V from a 12 V supply of negligible internal resistance. A number of identical resistors is available.

(i) Complete Fig. 3.1 to show a potential divider arrangement which could be used.

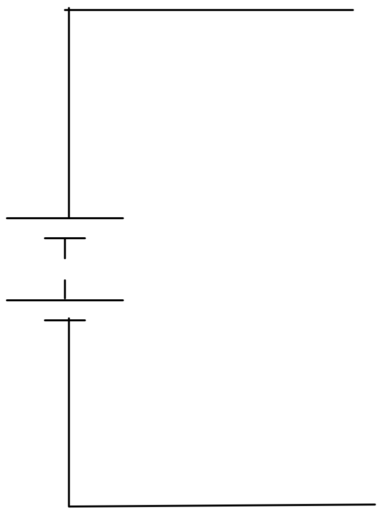


Fig. 3.1

[1]

(ii) On Fig. 3.1 show the connections made to the circuit for each potential difference. **[2]**

4 **(a)** Fig. 4.1 shows the magnetic field of a wire P carrying a steady current *I* perpendicular and into the plane of the paper.

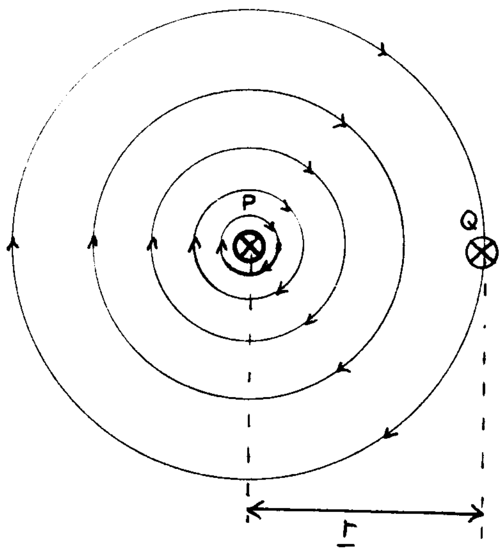


Fig. 4.1

A second wire Q, parallel to P and at a distance r from P, carries an equal current I, also into the plane of the paper.

(i) On Fig. 4.1, mark and label with a letter N a point where the resultant magnetic flux density produced by the two currents is zero **[2]**

(ii) Explain why the magnetic flux density at N is zero.

....

....

.... **[2]**

(iii) On Fig. 4.1, draw arrows to show the directions of the electromagnetic forces experienced by P and by Q. Label these forces F_P and F_Q. Name the rule used to determine the directions of the forces F_P and F_Q.

....

[3]

(b) Fig. 4.2 shows an arrangement for measuring the magnetic flux density B between the poles of a magnet.

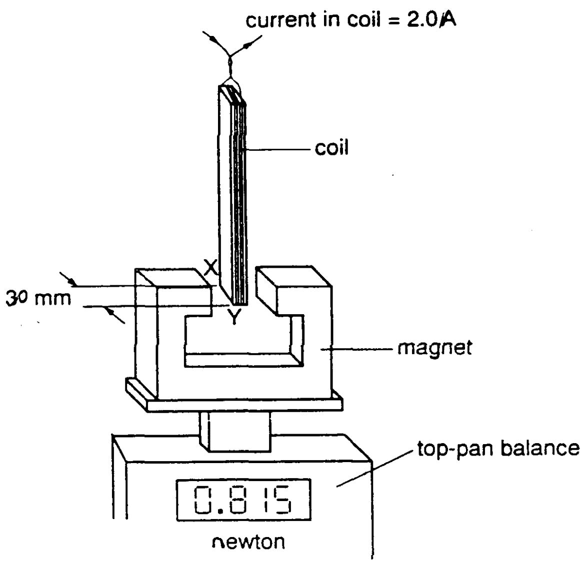


Fig. 4.2

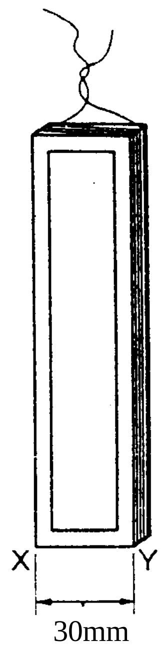


Fig. 4.3

The coil shown in Figs. 4.2 and 4.3 has 50 turns. Its lower side XY is horizontal and has a mean length of 30 mm. Before the current is switched on, the balance reading is 0.850 N. With a current of 2.0 A in the coil, the balance reading becomes 0.815 N.

(i) Determine the magnitude and direction of the electromagnetic force acting in the magnet.

force = ...N

direction..

[2]

(ii) Calculate the magnetic flux density B between the poles of the magnet.

B = ... **[3]**

5 **(a)** An insulated zinc plate has a negative charge. When ultra-violet radiation is incident on the plate, the plate rapidly loses its negative charge. Explain what is happening to cause this effect.

....

....

....

.... **[4]**

(b) Einstein analysed the phenomenon described in (a) and derived the equation

$$hf = f + \tfrac{1}{2}mv_{max}^2$$

(i) State what each of the three terms in the equation represents.

hf..

f...

....

$\tfrac{1}{2}mv_{max}^2$...

.... **[3]**

(ii) Calculate the value of *hf* for ultra-violet light of frequency 4.7 x 10^{15} Hz.

hf = ...

[2]

(c) **(i)** Briefly describe how the wave nature of electrons may be demonstrated.

....

....

....

.... **[4]**

(ii) Calculate the de Broglie wavelength of electrons travelling at a speed of 5.0 x 10^7 m s^{-1}.

wavelength = ………………m **[3]**

6 **(a)** State two features which are common to all sections of the electromagnetic spectrum.

1. ....

2. ....

[2]

(b) Fig 6.1 is a part completed table summarising several features of different sections of the electromagnetic spectrum. Complete the table with brief statements for six sections of the spectrum.

radiation	typical wavelength	method of production	a use	
gamma (γ)				**[3]**
	10^{-10} m	stopping high speed electrons at a target		**[2]**
	10^{-8} m			**[3]**
light		from very hot objects	sight, photography	**[1]**
infra-red			heat from the sun	**[2]**
	10 m	high frequency oscillation of electrons		**[2]**

Quality of written communication [4]

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

Physics A

ELECTRONS AND PHOTONS **2822**

Mark Scheme

1	**(a)**	**(i)**	charge = current x time	B1	
		(ii)	coulomb	B1	
		(iii)	Work done per unit charge	M1	
			in converting electrical energy to some other form of energy	A1	
			Volt: joule per coulomb	B1	**[5]**
	(b)	**(i)**	conventional current and electron flow in opposite directions	M1	
			directions correct	A1	
		(ii)	*energy* = *p.d.* x *charge* = 6 x 15	C1	
			= 90 J	A1	**[4]**
	(c)	**(i)**	$V = IR$	C1	
			= 4 x 2.0 = 8.0 V	A1	**[2]**
		(ii)	current in R_2 = 1A	C1	
			p.d. across R_2 = 8 V	C1	
			$\therefore R_2 = 8\ \Omega$	A1	**[3]**
		(iii)	p.d. across R_1 = 12 - 8 = 4 V	A1	**[1]**
		(iv)	R_1 = 4 / 5	C1	
			= 0.80 Ω	A1	**[2]**
2	**(a)**	**(i)**	$R = \rho l / A$	C1	
			= $(8.0 \times 10^{-5} \times 0.6) / (4.0 \times 10^{-7})$	M1	
			= 120 Ω	A1	**[3]**
		(ii)	total resistance = 120 / 4		
			(or using long winded method, -1 each error)	C2	
			= 30 Ω	A1	**[3]**
		(iii)	Power = V^2 / R	C1	
			= $230^2 / 30$	C1	
			= 1760 W	A1	**[3]**
		(iv)	energy = 1.76 x 8	C1	
			= 14.1 kW h	A1	**[2]**
	(b)	**(i)**	resistance increases	M1	
			valid explanation	A1	
		(ii)	power reduced	M1	
			valid explanation	A1	**[4]**
	(c)	**(i)**	graph initially straight through origin	B1	
			curve with decreasing gradient	B1	
		(ii)	as current increases temperature rises	M1	
			resistance increases with temperature		
			(so gradient is less)	A1	**[4]**
3	**(a)**	**(i)**	energy converted from some form into electrical energy	M1	
			per unit charge	A1	
		(ii)	resistance within battery	M1	
			which prevents all the energy supplied by cell being		
			used in external circuit.	A1	**[4]**

	(b)	**(i)**	resistors in series	B1	
		(ii)	p.d. of 4 V shown correctly	B1	
			p.d. of 8 V shown correctly	B1	**[3]**
4	**(a)**	**(i)**	between P and Q	M1	
			midway	A1	**[2]**
		(ii)	fields in opposite direction	B1	
			and of equal magnitude	B1	**[2]**
		(iii)	Force on P correct (inwards)	B1	
			opposite force on Q	B1	
			Fleming's left hand rule	B1	**[3]**
	(b)	**(i)**	0.035 N	B1	
			upwards	B1	**[2]**
		(ii)	$F = BIl$	C1	
			$0.035 = B \times 2.0 \times (50 \times .030)$	C1	
			$B = 0.012$ T	A1	**[3]**
5	**(a)**		photons	B1	
			give their energy to electrons	B1	
			causing electrons to be ejected	B1	
			and electrons carry negative charge	B1	**[4]**
	(b)	**(i)**	energy of photon	B1	
			work function of surface *(or explained)*	B1	
			(maximum) kinetic energy of photoelectrons	B1	**[3]**
		(ii)	$E = hf = 6.63 \times 10^{-34} \times 4.7 \times 10^{15}$	C1	
			$= 3.12 \times 10^{-18}$ J	A1	**[2]**
	(c)	**(i)**	electrons aimed at carbon film (in vacuum)	M1	
			rings seen on screen	A1	
			which is diffraction pattern	A1	
			any further detail	A1	**[4]**
		(ii)	$l = h / mv$	C1	
			$= (6.63 \times 10^{-34}) / (9.31 \times 10^{-31} \times 5.0 \times 10^{7})$	C1	
			$= 1.46 \times 10^{-11}$ m	A1	**[3]**
6	**(a)**		e.g. can travel through a vacuum		
			travel at the same speed		
			can show wave properties		
			1 mark each	B2	**[2]**

(b)	gamma	10^{-11} - 10^{-13} m	radioactive sources	cancer treatment		
	X-rays	10^{-10} m	stopping high-speed electrons	X-ray photographs		
	U.V	10^{-8} m	special sun lamps	tanning		
	light	5 x 10^{-7} m	very hot objects	sight		
	infra-red	10^{-6} m	hot objects	heat from Sun		
	radio	10 m	high f. oscillations of e's	telecom.		
	1 mark for each correct response				B13	**[13]**

Quality of Written Communication **[4]**

ELECTRONS AND PHOTONS

ASSESSMENT GRID

Question Number		Learning Outcome	AO1	AO2	AO3	AO4	Section sub-total	Question total
1	**(a) (i)**	1 (c)	1				1	
	(a) (ii)	1 (d)	1				1	
	(a) (iii)	1 (f)	3				3	
	(b) (i)	1 (e)	1	1			2	
	(b) (ii)	1 (g)	1	1			2	
	(c) (i)	1 (j)	1	1			2	
	(c) (ii)	1 (j)	1	2			3	
	(c) (iii)	2(j)		1			1	
	(c) (iv)	2(j)	1	1			2	17
2	**(a) (i)**	1 (m)	1	2			3	
	(a) (ii)	2 (i)	1	2			3	
	(a) (iii)	1 (n)	1	2			3	
	(a) (iv)	1 (o) (p)	1	1			2	
	(b) (i)	2 (i)	1	1			2	
	(b) (ii)	1 (n)	1	1			2	
	(c) (i)	1 (h)	1	1			2	
	(c) (ii)	1(h)	1	1			2	19
3	**(a) (i)**	2 (c)	1	1			2	
	(a) (ii)	2 (e)	2				2	
	(b) (i)	2 (b) (k)	1	1			2	
	(b) (ii)	2 (b) (k)		1			1	7
4	**(a) (i)**	3 (a)	1	1			2	
	(a) (ii)	3 (a)	1	1			2	
	(a) (iii)	3 (c)	2	1			3	
	(b) (i)	3 (c), Mod A		2			2	
	(b) (ii)	3 (c)	1	2			3	12
5	**(a)**	4 (a)	4				4	
	(b) (i)	4 (g)	1	2			3	
	(b) (ii)	4 (g)		2			2	
	(c) (i)	4 (j)	4				4	
	(c) (ii)	4 (jk)	1	2			3	16
6	**(a)**	5 (a)	2				2	
	(b)	5 (a)(b)	11	2			13	15
Quality of Written Communication			2	2			4	4
			54	36			90	90

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

Physics A

WAVE PROPERTIES **2823/01**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 60 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Answer all the questions in the space provided.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$m_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$e_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + ½at^2$ $v^2 = u^2 + 2as$
refractive index,	$n = 1/\sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0\ e^{-t/CR}$
pressure of an ideal gas,	$p = Nm<c^2> / 3V$
radioactive decay,	$x = x_0\ e^{-mt}$ $l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^{\ 2} / 8\pi G$
relativity factor,	$g = \sqrt{\{1 - v^2/c^2\}}$
sound intensity level,	$I.L. = 10\ \lg(I/I_0)$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$

Answer **all** the questions in the spaces provided.

1 **(a)** State the laws of refraction of light. Illustrate your answer with a diagram.

....

....

....

....

....

....

…….. **[3]**

(b) Light is travelling in glass X with speed 1.9568×10^8 m s^{-1}. It reaches a boundary with a different glass Y at an angle slightly greater than the critical angle of 87.60° and undergoes total internal reflection.

(i) Explain, with the aid of a diagram, what is meant by the terms

1. critical angle,

....

....

....

....

2. total internal reflection.

....

....

....

....

[3]

(ii) Calculate the speed of light in glass Y.

speed of light in Y = ...m s^{-1} **[4]**

(c) Calculations similar to that in **(b)** are important when considering the passage of a pulse of light along an optic fibre. A fibre of length 10 km is made out of glass X. Some light is continually being reflected by the walls of the fibre, always having an angle of incidence equal to the critical angle.

Calculate the extra distance travelled by this light when compared to light travelling along the axis of the fibre.

extra distance = ...m **[4]**

(d) **(i)** Explain how the effect described in **(c)** causes dispersion of a pulse.

....

....

.... **[2]**

(ii) Suggest how this effect may be minimised.

....

....

....

....

[2]

2 **(a)** State three differences between a sound wave and a light wave.

1..

....

2..

....

3...…………………......

....…………………......

[3]

(b) Sound waves are produced in air by a loudspeaker connected to a signal generator. The frequency of the waves is increased.
State the effect, if any, of this increase on

(i) the speed of the waves,

....……………………….................... **[1]**

(ii) the wavelength of the waves.

....………………………….................

[1]

(c) Calculate the frequency required in **(b)** for the waves to have a wavelength of 84 cm when the speed of the waves is 340 m s^{-1}.

frequency = ...… **[2]**

3 A stretched string on a stringed instrument has a vibrating length of 1.16 m. It is bowed to set it oscillating and it is observed to undergo oscillations, as illustrated in Fig. 3.1

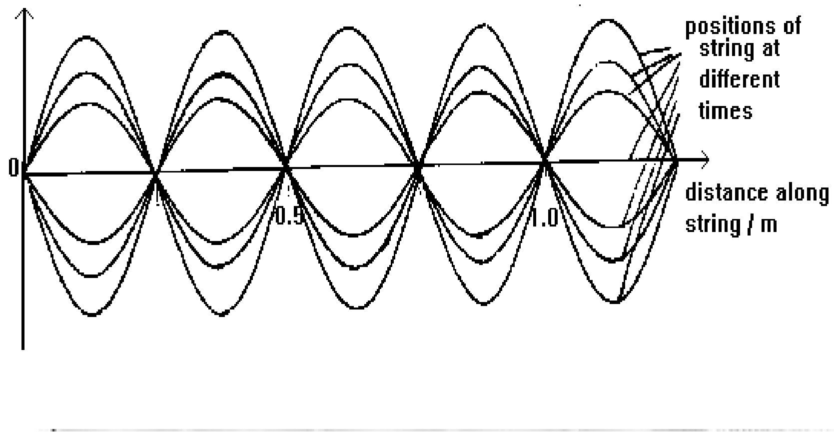


Fig. 3.1

(a) **(i)** Is this wave a progressive wave or a standing wave?

.... **[1]**

(ii) Is this wave a transverse wave or a longitudinal wave?

.... **[1]**

(b) Explain how, as a result of the bow moving the string, this wave is formed.

....

....

....

....

....

....

[4]

(c) From Fig. 3.1 deduce

(i) the distance between two nodes,

distance = ... m**[1]**

(ii) the wavelength of the wave.

wavelength = ... m **[1]**

(d) Discuss briefly whether such a wave can be polarised.

....

....

.... **[3]**

(e) Give experimental details of how you would extend the investigation described in this question in order to determine the speed of the wave on the string.

....

....

....

....

....

....

....

....

....

....

....

....

....

.... **[6]**

4 **(a)** State three conditions which must be satisfied for two waves to produce observable interference.

1...

2...

3. .... **[3]**

(b) In order to measure the wavelength of light from a monochromatic lamp a two-source interference experiment is used.

(i) Draw a labelled diagram of suitable apparatus to observe two-source interference. **[4]**

(ii) Describe how you would take the measurements which are required in order to determine the wavelength of the light from the lamp.

....

....

....

....

....

....

.... **[4]**

(iii) Explain how you would use these measurements to determine the wavelength of the light.

....

....

....

.... **[2]**

5 **(a)** Explain the meaning of the term *diffraction*.

....

....

.... **[2]**

(b) Describe how you could demonstrate diffraction of waves on water.

....

....

....

....

....

....

....

....

....

.... **[3]**

Oxford Cambridge and RSA Examinations

Advanced Subsidiary GCE

Physics A

WAVE PROPERTIES **2823/01**

Mark Scheme

1	**(a)**		Both rays and normal in the same plane	B1	
			sin*i* / sin*r* = constant	B1	
			diagram showing rays and angles	B1	**[3]**
	(b)	**(i)**	1. light travelling from more dense to less dense	B1	
			critical angle when angle of refraction = 90°	B1	
			2. reflection if incident angle greater than the critical angle	B1	**[3]**
		(ii)	${}_{Y}n_{X} = c_{Y} / c_{X}$	B1	
			$= 1 / \sin C$	B1	
			$c_{Y} / (1.9568 \times 10^{8}) = 1 / \sin 87.60$	C1	
			$c_{Y} = 1.9585 \times 10^{8}$ m s^{-1}	A1	**[4]**
	(c)		distance along axis = hypotenuse distance x sin 87.60°	C1	
			10 / sin87.60 = distance along hypotenuse	C1	
			= 10.0088 km	C1	
			extra distance = 8.8 m	A1	**[4]**
	(d)	**(i)**	the pulse starts to arrive at a certain time but some of it is slower to arrive if path is longer	B1	
			effect is to broaden the pulse	B1	**[2]**
		(ii)	e.g. keep the critical angle as high as possible	B1	
			make the fibre as thin as possible	B1	**[2]**
2	**(a)**		e.g.. sound requires a medium, light does not		
			sound at much lower speed		
			sound is longitudinal, light is transverse		
			l each, max 3	B3	**[3]**
	(b)	**(i)**	no effect	B1	**[1]**
		(ii)	decreases	B1	**[1]**
	(c)		$f = c / l = 340 / 0.84$	C1	
			= 405 Hz	A1	**[2]**
3	**(a)**	**(i)**	standing	B1	**[1]**
		(ii)	transverse	B1	**[1]**
	(b)		bow makes a point on the string oscillate	B1	
			which sends out waves in both directions along the string	B1	
			these waves are reflected at both ends	B1	
			and come back through one another, causing interference	B1	**[4]**
	(c)	**(i)**	1250 / 5 = 250 mm	B1	**[1]**
		(ii)	500 mm	B1	**[1]**
	(d)		can be polarised	B1	
			but not likely to be	M1	
			since bow will make string vibrate in more than one plane	A1	**[3]**

	(e)	need to find frequency, then *c* = *f l*		B1	
		use c.r.o. and microphone		B1	
		microphone connected to Y-plates		B1	
		adjust t.b. to give sketched pattern		B1	
		measure length ‘*d*’ of wave		B1	
		frequency = 1 / *d* x t.b. setting		B1	**[6]**
4	**(a)**	e.g. same type of wave			
		meeting at a point			
		approximately same amplitude			
		same frequency / wavelength			
		constant phase difference			
		l each, 3 max		B3	**[3]**
	(b)	**(i)** diagram:	lamp with single slit or laser	B1	
			double slit		
				B	
			1		
			screen / microscope		
				B	
			1		
			indication of dimensions	B1	**[4]**
		(ii)	measure *a* and *d*	B1	
			suitable equipment mentioned	B1	
			move across as many fringes as possible	B1	
			measure D with a ruler	B1	**[4]**
		(iii)	*x* = measurement distance / number of fringes	B1	
			l = *ax* / *D*	B1	**[2]**
5	**(a)**	when wavefront is restricted / meets edge or gap		M1	
		wavefront travels into geometrical shadow / wave bends at corners		A1	**[2]**
	(b)	apparatus outlined			
				B	
		1			
		how operated		B1	
		description / diagram of what seen		B1	**[3]**

WAVE PROPERTIES

ASSESSMENT GRID

Question Number	Learning Outcome	AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a)	1 (a)	3				3	
(b) (i)	1 (c)	3				3	
(b) (ii)	1 (b) (c) (d)	1	3			4	
(c)	1 (e)		4			4	
(d) (i)	1 (f)	1	1				
(d) (ii)	1(f)		2			4	18
2 (a)	2 (c) (g)	3				3	
(b) (i)	2 (c)	1					
(b) (ii)	2 (c)	1				2	
(c)	2 (e)	1	1			2	7
3 (a) (i)	2 (f), 3 (d)	1					
(a) (ii)	2 (g) (h)	1				2	
(b)	2 (e)	2	2			4	
(c) (i)	2 (e)		1				
(c) (ii)	2 (e)		1			2	
(d)	2 (i)	1	2			3	
(e)	2 (j) (e)	3	3			6	17
4 (a)	3 (a) (b)	3				3	
(b) (i)	3 (h)	3	1			4	
(b) (ii)	3 (h)	3	1			4	
(b) (iii)	3 (i)	1	1			2	13
5 (a)	3 (f)	2				2	
(b)	3 (g)	2	1			3	5
		36	24			60	60

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

FORCES, FIELDS AND ENERGY **2824**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Answer all the questions in the space provided.

Answer **all** the questions in the spaces provided.

1 **(a)** **(i)** Define (linear) *momentum.*

....

.... **[2]**

(ii) State whether momentum is a scalar or a vector quantity.

....

[1]

(b) State the principle of conservation of (linear) momentum.

....

....

.... **[2]**

(c) In a particular collision, a piece of plasticene of mass 0.20 kg falls and hits the ground with a vertical velocity of 8.0 m s^{-1}. It does not bounce but sticks to the ground.

(i) Calculate the momentum of the plasticene just before it hits the ground.

momentum = ... **[1]**

(ii) State the transfers of momentum and of kinetic energy of the plasticene which occur as a result of the collision.

Momentum

……………………………………………………………...…………………

....………...

kinetic energy

……………………………………………………………………………..……

....………..............

[2]

(d) Two strong magnets are held stationary with the north pole of one pushed up against the north pole of the other. On letting go, the magnets spring apart. Explain how the law of conservation of momentum applies in this case.

....

....

.... **[2]**

2 A planet P of mass *m* orbits the Sun S of mass *M* in a circular orbit of radius *r* as shown in Fig. 2.1.

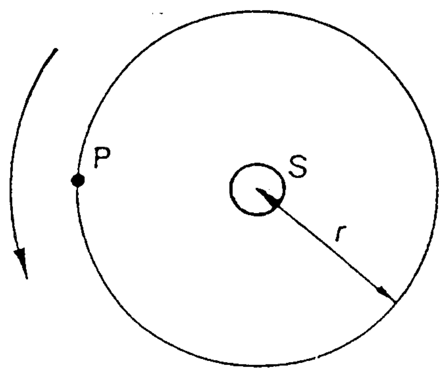


Fig. 2.1

The speed of the planet in its orbit is *v*.

(a) On Fig. 2.1, draw an arrow to represent the linear velocity of P. Label the arrow V. Draw a second arrow representing the direction of the force acting on P. Label this arrow F. **[2]**

(b) **(i)** Write down an expression, in terms of *r* and *v*, for the magnitude of the centripetal acceleration of P.

.... **[1]**

(ii) Write down an expression, in terms of *m*, *r* and *v*, for the magnitude of the force *F* acting on P.

.... **[2]**

(iii) Write down an expression, in terms of *m*, *M*, *r* and *G*, for the magnitude of the gravitational force exerted by the Sun on the planet.

.... **[1]**

(c) From observations of the motions of the planets around the Sun, Kepler (1571 - 1630) found that T^2, the square of the period of revolution of a planet around the Sun, was proportional to r^3.

(i) Write down an expression for T in terms of the speed v of the planet and the radius r of its orbit.

.... **[1]**

(ii) Use your answers to **(b)(ii)**, **(b)(iii)** and **(c)(i)** to show Kepler's relation

$$T^2 \propto r^3$$

would be expected.

....

....

.... **[2]**

3 A block of wood floats in still water as shown in Fig. 3.1.

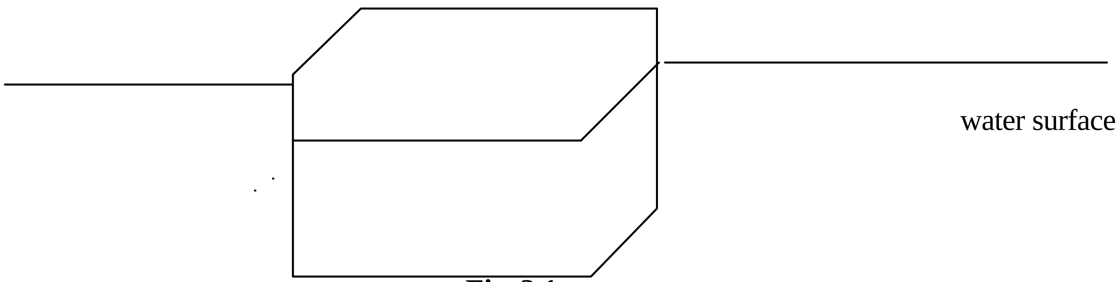


Fig. 3.1

When the block is pushed down into the water, without totally submerging it, and is then released, it bobs up and down in the water with frequency f. The vertical motion of the block is simple harmonic.

(a) Explain what is meant by *simple harmonic* motion.

....

.... **[2]**

(b) Suggest why f is the natural frequency of vibration of the block in the water.

....

.... **[1]**

(c) Surface water waves of speed 0.90 m s^{-1} and wavelength 0.30 m are then incident on the Block. These cause resonance in the vertical motion of the block.

(i) Explain what is meant by *resonance*.

....

.... **[2]**

(ii) Calculate the frequency of the water waves.

frequency = ...Hz **[2]**

(iii) State the resonant frequency of the block in the water.

frequency = ... Hz **[1]**

4 **(a)** State two pieces of information that can be deduced from drawings of electric field lines

1. ....

2. ....

[2]

(b) Fig. 4.1 illustrates some of the electric charges in a thundercloud and on the surface of the Earth beneath it.

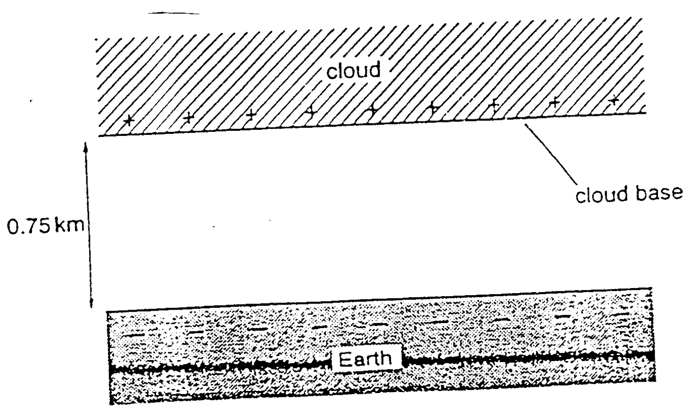


Fig 4.1

The base of the cloud and the surface of the Earth can be considered horizontal.

(i) On Fig. 4.1, sketch the electric field between the cloud and the Earth. **[3]**

(ii) The cloud base is 0.75 km above the Earth. A lightning flash occurs in air containing raindrops when the electric field strength exceeds 5.0×10^{4} N C^{-1}. Calculate the minimum electric potential difference between the cloud base and the Earth's surface for a lightning flash to occur.

potential difference = ... V
[2]

5 **(a)** **(i)** On Fig 5.1, sketch a graph to show the variation with charge *Q* of the potential difference *V* across a capacitor. **[2]**

Fig. 5.1

(ii) Hence define what is meant by the *capacitance* of the conductor.

....

.... **[2]**

(b) A capacitor of capacitance 5000 μF is connected in series with a resistor of resistance 12000 Ω and a switch S, as shown in Fig. 5.2.

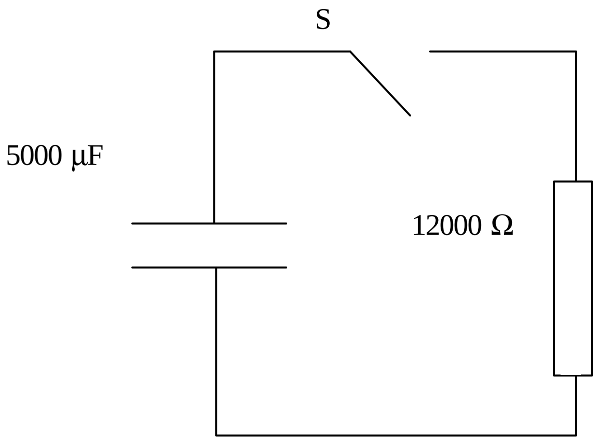


Fig. 5.2

Initially, the switch is open and the capacitor has a potential difference across it of 9.0 V. When S is closed, the variation with time *t* of the potential difference *V* across the capacitor is given by the expression

$$V = V_0 e^{-t/t}.$$

(i) Calculate the time constant *t*,

t = ... **[3]**

(ii) Calculate the time after S is closed before the potential difference across the capacitor is 4.5 V.

time = ...s **[3]**

6 Fig. 6.1 shows the front view of a pivoted square coil. The plane of the coil is at right angles to a uniform magnetic field directed into the paper. Fig. 6.2 is a side view of the same coil.

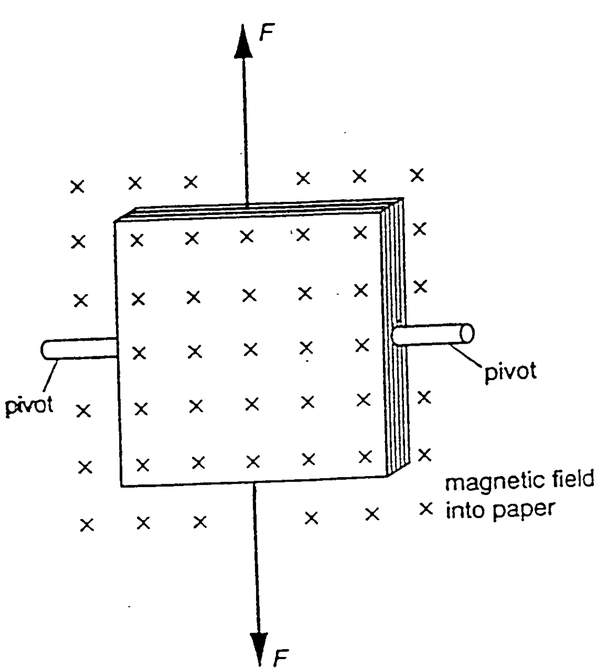


Fig. 6.1

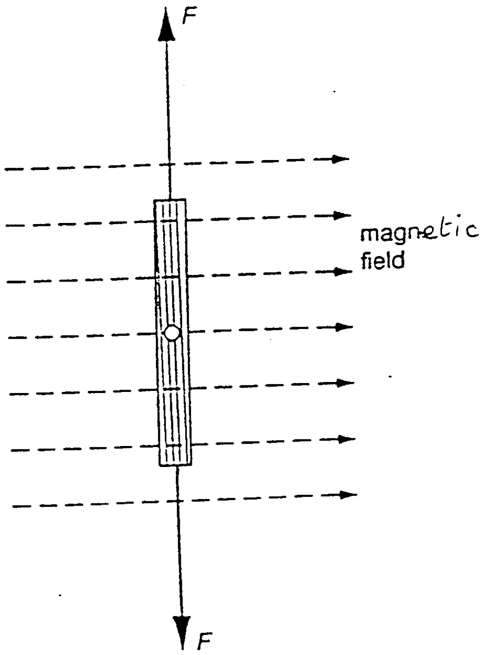


Fig. 6.2

(a) The coil conducts a current causing electromagnetic forces to act on the coil. The directions of the forces *F* on the upper and lower sides are shown in both Figures.

On Fig. 6.1, draw and label arrows to show the directions of

(i) the current in the coil, **[1]**

(ii) the electromagnetic forces acting on the other sides of the coil. **[2]**

(b) Suggest why the forces in **(a)(ii)** are not considered when calculating the torque produced by the coil.

....

....

....

.... **[3]**

7 Fig. 7.1 shows the magnetic field between the two pole pieces of a large U-shaped magnet, with the north pole vertically above the south pole. When the strength of the magnetic field is measured along the line AB, it is found to vary as shown in Fig. 7.2.

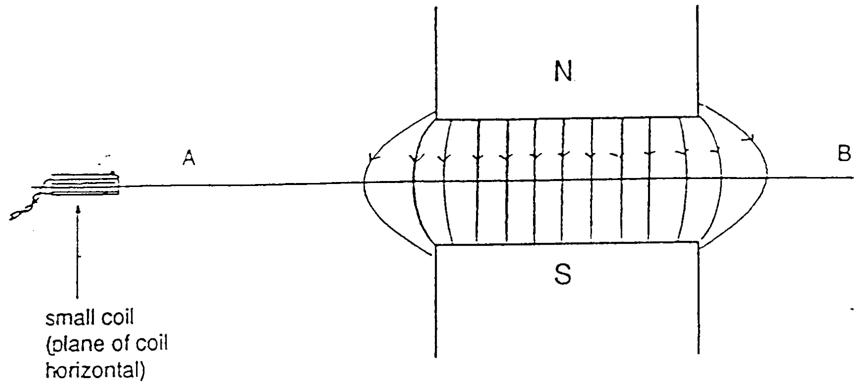


Fig. 7.1

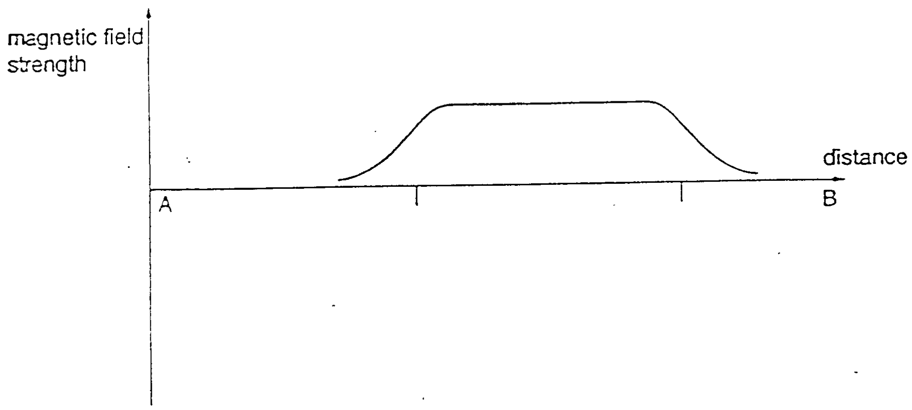


Fig. 7.2

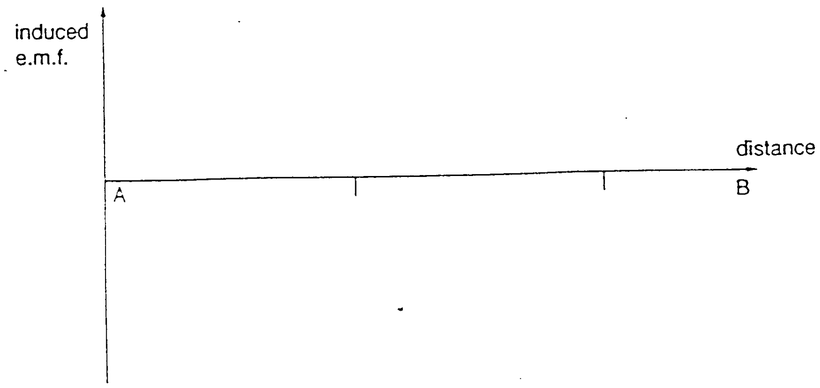


Fig. 7.3

(a) Describe in words how the magnetic flux linkage in the coil changes as the coil in Fig. 7.1 moves from A to B.

....

....

....

.... **[3]**

(b) State Faraday's law of ele ctromagnetic induction.

....

....

.... **[2]**

(c) Draw, on the axes provided in Fig. 7.3, a graph to show how the e.m.f. induced in the coil varies as the coil moves from A to B. **[4]**

8 **(a)** The pressure *p* of an ideal gas is related to its volume V and thermodynamic temperature T by the ideal gas equation. State the ideal gas equation , explaining any other symbols used.

....

....

.... **[2]**

(b) Explain what is meant by the absolute zero of temperature.

…..

….. **[1]**

(c) **(i)** The pressure of this air in a room of volume 54 m^3 is 1.0 x 10^5 Pa. The temperature of the air, assumed to be ideal, is 17°C. Calculate the amount of gas, in mol., in the room.

……………………………………………………………………………....…………..

……………………………………………………………………………..……….

……………………………………………………………………………..……….

[2]

(ii) On a hot summer's day, the pressure of the air is found to be 1.02×10^5 Pa and the temperature is 32°C. Calculate the change in the mass of air in the room, given that 1 mol. of air has mass 30g.

……………………………………………………………………………..……………..

……………………………………………………………………….………………..

…………………………………………………………………….………….……..

……………………………………………………………………….………….…..

……………………………………………………………………….………….…..

[3]

9 **(a)** Define *specific heat capacity*.

....

.... **[2]**

(b) A mass of 1.5 kg of water at 10°C is supplied continuously with thermal energy.

The specific heat capacity of water is 4.2×10^3 J kg^{-1} K^{-1}.

(i) Calculate the energy required to raise the temperature of the water to 100°C.

energy = ... **[2]**

(ii) Although the supply of thermal energy is continued the temperature of the water remains at 100°C .

Explain this observation.

…………………………………………………………………………………… **[1]**

10 **(a)** Outline briefly the experimental evidence provided by an α-particle scattering experiment for

(i) an atom containing a very small nucleus,

....

....

.... **[2]**

(ii) the nucleus being charged.

....

....

.... **[2]**

(b) Name the effect which enables the following to be measured.

(i) spacing between atoms in crystals

.... **[1]**

(ii) nuclear radii

.... **[2]**

11 **(a)** The radioactive isotope Polonium-218 has a half-life of 3.0 minutes. A pure sample initially contains 6.0×10^{15} Polonium-218 nucleii.

(i) Show that the number of polonium nucleii remaining after 7.0 minutes is 1.2×10^{15}.

[2]

(ii) Calculate the activity of the sample of polonium after 7.0 minutes.

activity = ... Bq
[2]

(b) In an experiment, a detector is held a fixed distance from a sample of a radioactive material and the data provided is used to plot a graph of count-rate against time.

(i) Explain why the data points on the graph do not lie on a smooth curve.

....

....

.... **[1]**

(ii) Suggest two reasons why the count-rate recorded is not the same as the activity of the sample.

1. ....

....

2. ....

....

[2]

Quality of Written Communication [4]

[Total: 90]

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

FORCES, FIELDS AND ENERGY **2824**

Mark Scheme

1	**(a)**	**(i)**	mass x velocity (allow ½ for 'speed')	B2	
		(ii)	vector	B1	**[3]**
	(b)		total momentum before = total momentum after	B1	
			in an isolated system	B1	**[2]**
	(c)	**(i)**	momentum = 1.6 Ns (include unit)	B1	
		(ii)	(most) transferred to Earth	B1	
			E_k seen as thermal energy in plasticene and Earth	B1	**[3]**
	(d)		each has equal momentum but opposite direction	M1	
			so momentum always conserved / zero	A1	**[2]**
2	**(a)**		velocity arrow correct	B1	
			force direction correct	B1	**[2]**
	(b)	**(i)**	$a = v^2/r$	B1	
		(ii)	$F = ma$	C1	
			$F = mv^2/r$	A1	
		(iii)	$F = GMm/r^2$	B1	**[4]**
	(c)	**(i)**	$T = 2\pi r/v$	B1	
		(ii)	equating GMm/r^2 and mv^2/r	M1	
			eliminating v idea	M1	
			maths / algebra leading to $T^2 \propto r^3$	A0	**[3]**
3	**(a)**		acceleration $\propto$ displacement from point	M1	
			and directed towards point	A1	**[2]**
	(b)		block allowed to vibrate freely	B1	**[1]**
	(c)	**(i)**	block vibrates with maximum amplitude	B1	
			when impressed frequency equals natural frequency	B1	
		(ii)	$c = f\lambda$	C1	
			$f = 3.0$ Hz	A1	
		(iii)	3.0 Hz	B1	**[5]**
4	**(a)**		e.g. direction, strength, change in magnitude *1 each*	B2	**[2]**
	(b)	**(i)**	sketch: parallel lines	B1	
			equally spaced	B1	
			correct direction	B1	
		(ii)	$E = V/d$		
			$5.0 \times 10^4 = V / 0.75 \times 10^3$	C1	
			$V = 3.8 \times 10^7$ V	A1	**[5]**
5	**(a)**	**(i)**	graph: straight line	M1	
			passing through origin	A1	

		(ii)	reference to graph gradient	B1	
			capacitance = Q/V	B1	**[4]**
	(b)	**(i)**	$t = CR$	C1	
			$= 60$	A1	
			seconds	A1	**[3]**
		(ii)	$4.5 = 9.0e^{-t/60}$	C1	
			$0.693 = t/60$	C1	
			$t = 42$ s	A1	**[3]**
6	**(a)**	**(i)**	current direction correct	B1	
		(ii)	correct direction on one side	M1	
			opposite direction on other	A1	**[3]**
	(b)		forces always along axis	M1	
			torque = Fx	M1	
			and $x = 0$	A1	**[3]**
7	**(a)**		increases	M1	
			to a constant value	A1	
			then decreases	B1	**[3]**
	(b)		induced e.m.f. proportional to rate of change of flux	M1	
			linkage	A1	**[2]**
	(c)		pulses	M1	
			of reasonable shape	A1	
			in opposite directions	B1	
			with region of zero e.m.f. between	B1	**[4]**
8	**(a)**		$pV = nRT$	M1	
			n and R explained	A1	**[2]**
	(b)		temperature at which ideal gas molecules have no kinetic energy	B1	**[1]**
	(c)	**(i)**	$1.0 \times 10^5 \times 54 = n \times 8.31 \times 290$	C1	
			$n = 2.24 \times 10^3$	A1	
		(ii)	$n = (1.02 \times 10^5 \times 54)/(8.31 \times 305)$		
			$= 2.17 \times 10^3$ mol	C1	
			change in n = 70 mol	C1	
			change in mass = 2.1 kg	A1	**[5]**

9	**(a)**		energy to raise temp of unit mass of substance by one degree	M1	
			with no change in temperature	A1	**[2]**
	(b)	**(i)**	$\Delta Q = mc\,\Delta T$		
			$= 1.5 \times 4.2 \times 10^3 \times 90$	C1	
			$= 5.7 \times 10^5$ J	A1	
		(ii)	Water is boiling	B1	**[3]**
10	**(a)**	**(i)**	most alphas have small deflection	M1	
			so nucleus is small target	A1	
		(ii)	deflection too large to be gravitational	M1	
			so must be electrostatic i.e. charged	A1	**[4]**
	(b)	**(i)**	X-ray diffraction or neutron diffraction or electron diffraction	B1	
		(ii)	high energy	M1	
			electron scattering	A1	**[3]**
11	**(a)**	**(i)**	$l = 0.693 / t_{½} = 3.85 \times 10^{-3}$ s^{-1}	C1	
			$N = 6.0 \times 10^{15} \exp(-3.85 \times 10^{-3} \times 7 \times 60)$	M1	
			$= 1.2 \times 10^{15}$	A0	
		(ii)	activity $= 3.85 \times 10^{-3} \times 1.2 \times 10^{15}$	C1	
			$= 4.6 \times 10^{12}$ Bq	A1	**[4]**
	(b)	**(i)**	random nature of emissions	B1	
		(ii)	e.g. self-absorption, detector not 100% efficient,		
			detector not surrounding source *l each*	B2	**[3]**
Quality of Written Communication				B4	**[4]**

[Total: 90]

FORCES, FIELDS AND ENERGY

ASSESSMENT GRID

Question Number		Learning Outcome	Assessment Objective AO1	AO2	AO3	AO4	Section sub-total	Question total
1	**(a)(i)**	Synoptic	2					
	(a)(ii)		1				3	
	(b)	1 (e)	2				2	
	(c)	1 (c), 2(a)	1	2			3	
	(d)	1 (f)		2			2	
2	**(a)**	3 (a)	1	1			2	
	(b) (i)	3 (c)	1					
	(b) (ii)	3 (d)	1	1				
	(b) (iii)	5 (d)	1				4	
	(c)	3 (c)	1	2			3	
3	**(a)**	4 (d)	1	1			2	
	(b)	4 (a) (k)		1			1	
	(c) (i)	4 (k) (l)	1	1				
	(c) (ii)	Mod C	1	1				
	(c) (iii)	4 (k)	1				5	
4	**(a)**	6 (c)	2				2	
	(b) (i)	6 (c)	1	2				
	(b) (ii)	6 (g)	1	1			5	
5	**(a) (i)**	7 (d)	1	1				
	(a) (ii)	7 (a)	1	1			4	
	(b) (i)	7 (h)	1	2				
	(b) (ii)	7 (i)		3			6	
6	**(a)**	8 (a)	1	2			3	
	(b)	Synoptic	1	2			3	
7	**(a)**	9 (c)	1	2			3	
	(b)	9 (d)	2				2	
	(c)	9 (f) (g)		4			4	
8	**(a)**	10 (i)	2				2	
	(b)	10 (c)	1				1	
	(c) (i)	10 (i)	2					
	(c)	10 (i)		3			5	
9	**(a)**	10 (i)	2				2	
	(b)	10 (g) (i)	1	2			3	

Question Number	Learning Outcome	Assessment Objective AO1	AO2	AO3	AO4	Section sub-total	Question total
10 (a)	11(a)	2	2			4	
(b) (i)	11 (b) (c) (d)	1					
(b) (ii)	11 (e)	2				3	
11 (a) (i)	12 (h) (k)	1	1				
(a) (ii)	12 (g)	1	1			4	
(b) (i)	12 (a)	1					
(b) (ii)	12 (h)		2			3	
Quantity of written communication		2	2			4	
		45	45			90	

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

COSMOLOGY **2825/01**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question,

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Questions 4 and 10 are synoptic in nature. In response to these questions, you are encouraged to bring together principles and concepts of physics to show comprehension, and to use skills of physics in the analysis of data.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$m_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$e_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + ½at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = 1 / \sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0 \, e^{-t/CR}$
pressure of an ideal gas,	$p = Nm<c^2> / 3V$
radioactive decay,	$x = x_0 \, e^{-mt}$,
	$l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^2 / 8\pi G$
relativity facto,	$\gamma = \sqrt{} \{1 - v^2 / c^2 \}$
sound intensity level,	$I.L. = 10 \lg(I / I_0)$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$

Answer **all** the questions in the spaces provided.

1 Fig. 1.1 shows an oblique view (not to scale) of the Earth's orbit as it would be seen from a point X outside the Solar System.

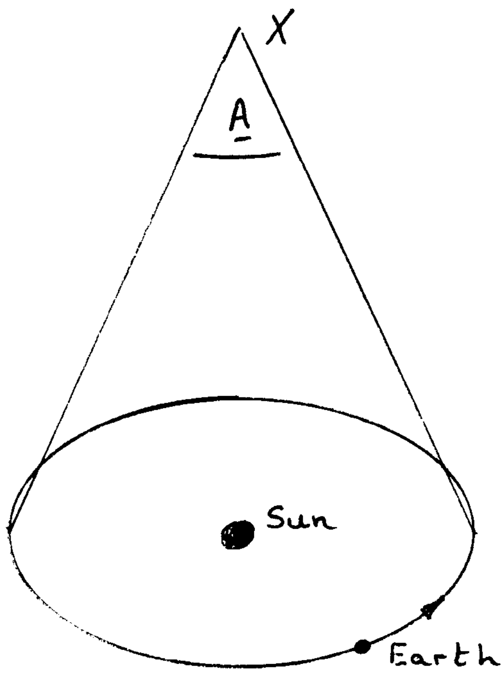


Fig. 1.1

(a) On Fig. 1.1, show what is meant by the *astronomical unit* (AU). **[1]**

(b) Given that X is at a distance of *n* parsecs (pc) from the Solar System, state the value of the angle *A* shown on Fig. 1.1.

A = ... seconds of arc **[2]**

2 The star Rigel (β Orionis) has an apparent magnitude of +0.3 and the star Canopus (α Carinae) has an apparent magnitude of -0.9. The apparent magnitude of a star is related to its intensity *I*
by the expression

$$m = -2.5 \lg I + \text{constant.}$$

(a) Show that the ratio

$$\frac{\text{intensity of light from Canopus seen at Earth}}{\text{intensity of light from Rigel seen at Earth}}$$

is equal to 3.02. **[2]**

....

....

....

.... **[2]**

(b) **(i)** State the relation between apparent magnitude *m*, absolute magnitude *M* and distance *r*.

.... **[1]**

(ii) For Rigel, *M* = -7.5. Calculate the distance of Rigel from Earth.

distance = ...

3 Fig. 3.1 is an outline of the Hertzsprung-Russell diagram.

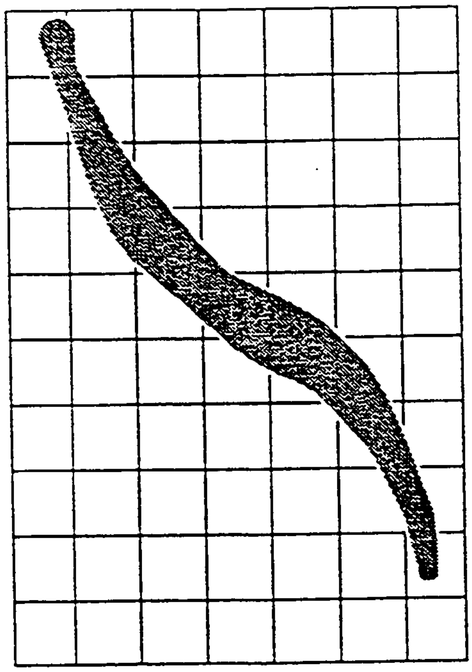


Fig. 3.1

(a) On Fig. 3.1,

(i) label the axes, **[2]**

(ii) mark the approximate position that currently represents the Sun (label this point S), **[2]**

(iii) name the region on the diagram in which the point S lies. **[1]**

(b) Also on Fig. 3.1,

(i) mark and name positions in two other regions that the Sun is expected to occupy. **[4]**

(ii) indicate the 'path' that the Sun is expected to take, as it evolves over the next 5×10^9 years. **[2]**

(c) State what is likely to be the final fate of the Sun (assuming that the Universe is open).

....

.... **[2]**

4 **(a)** State Kepler's third law which relates to the orbits of planets about the Sun. Also, state any assumption made about the nature of the orbit.

....

....

.... **[3]**

(b) A student wishes to test whether Kepler's third law applies to some of the satellites orbiting Uranus. The student obtains the data shown in Fig. 4.1 for the mean distance *d* of the satellite from Uranus and the period *T* of the rotation of the satellite about Uranus.

satellite	*d* / km	*T* / day	lg (*d*/km)	lg (*T*/day)
Rosalind	69 930	0.558	4.845	-0.475
Belinda	75 260	0.624	4.877	-0.205
Puck	86 010	0.762	4.935	-0.118
Miranda	129 780	1.414	5.110	0.150
Ariel	191 240	2.520	5.282	0.401
Umbriel	265 970	4.144	5.425	0.617
Titania	435 840	8.706	5.639	0.940
Oberon	582 600	13.463	5.765	1.129

Fig. 4.1

The student also includes values of lg *d* and lg *T* in order to plot a graph of lg *d* against lg *T*.

(i) Explain why the student decides to plot a graph of lg *d* against lg *T*.

....

....

.... **[2]**

(ii) On Fig. 4.2 plot the graph of lg *d* (*y*-axis) against lg *T* (*x*-axis). **[3]**

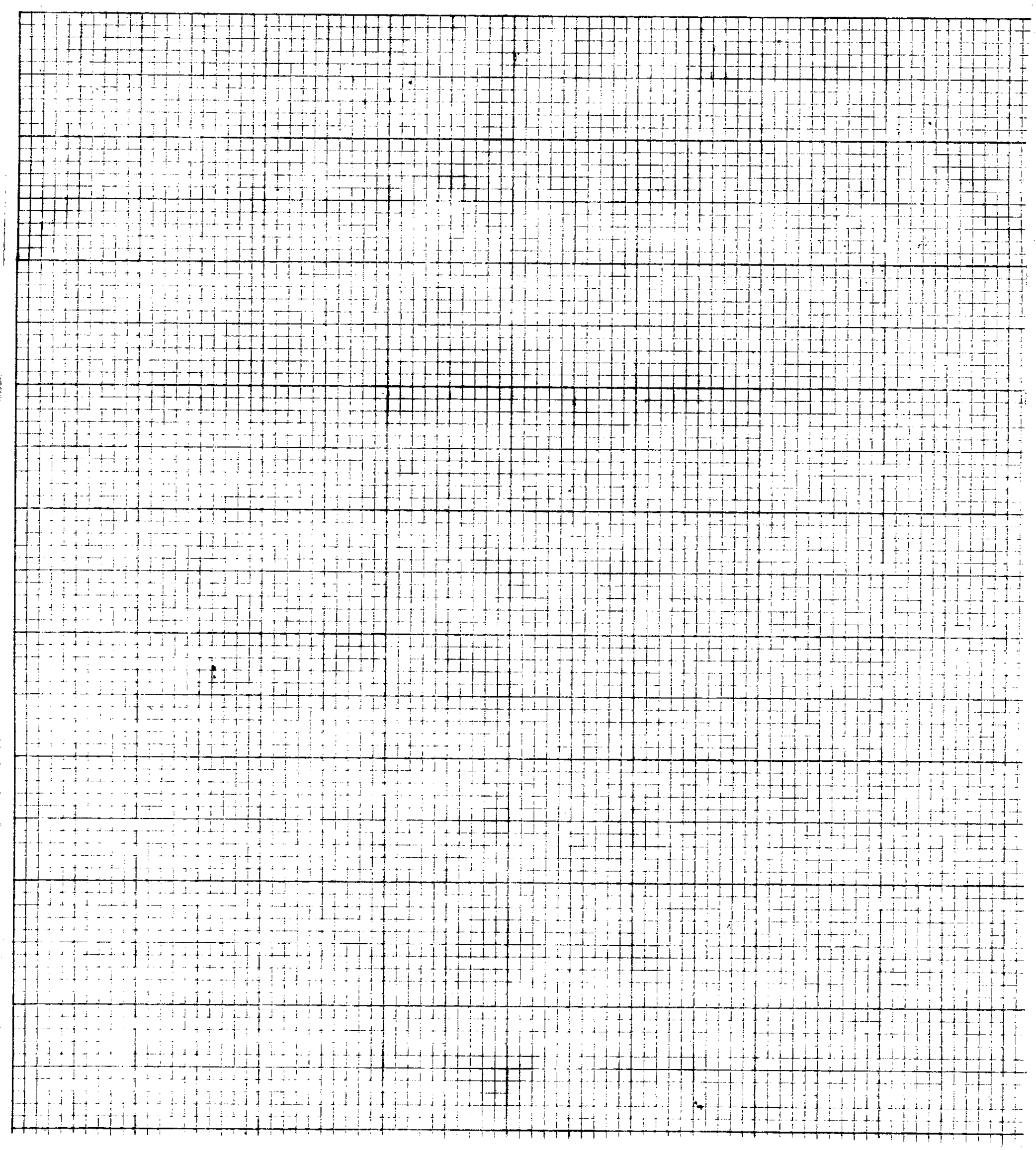


Fig. 4.2

(iii) Use your graph of Fig. 4.2 to determine whether Kepler's third law may apply to these satellites. **[3]**

(iv) Make two suggestions as to why your conclusion in (iii) must be treated with some reservation.

1. ....

....

2. ....

.... **[2]**

5 Olbers' paradox relates to a particular model of the Universe.

(a) State two important features of this model.

1. ....

....

2. ....

.... **[2]**

(b) What would be the appearance of the night sky, based on this model? Explain your answer.

....

....

....

....

.... **[4]**

6 Fig. 6.1 shows part of the electromagnetic spectrum.

wavelength ? x 10^{-9}/m

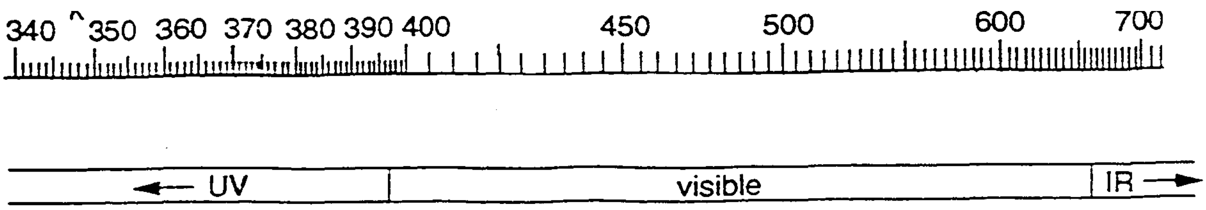


Fig. 6.1

A body moving with speed *v* relative to an observer emits light of wavelength *l*. The apparent change in wavelength of the emitted light is Δl.

(a) **(i)** State a Doppler equation relating Δl to *l*.

.... **[1]**

(ii) Use the data of Fig. 6.1 to calculate the minimum velocity of a blue star so, that it appears red to a stationary observer.

speed = ... m s^{-1}

direction ....

[4]

(b) Suggest whether, in practice, a red star could appear blue to an observer on Earth.

....

....

.... **[3]**

(c) The most distant stars show a *red shift*.

(i) What does this observation suggest about the Universe?

.... **[1]**

(ii) Briefly describe Hubble's conclusions based on red-shift observations.

....

....

.... **[2]**

7 The fate of the Universe is thought to depend on the mean density r of matter in the Universe.

(a) State what is meant by the *critical* mean density r_0 of matter in the Universe.

....

.... **[1]**

(b) Fig. 7.1 shows possible curves for the variation with time of the size of the Universe.

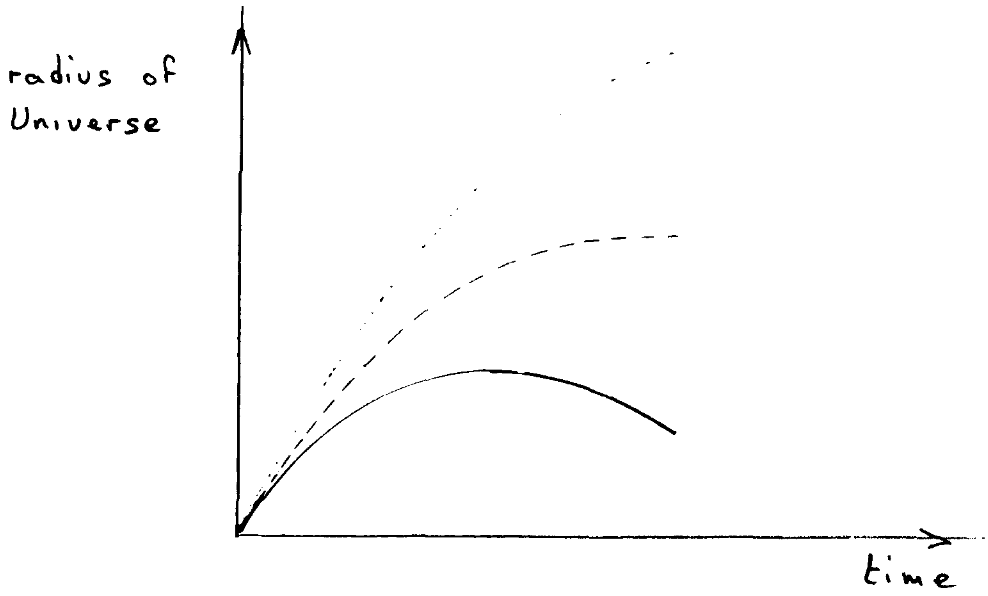


Fig. 7.1

On Fig. 7.1,

(i) label the curve corresponding to $r > r_0$, **[1]**

(ii) mark a point P corresponding to the present age of the Universe. **[1]**

(c) Suggest two reasons why the ultimate fate of the Universe is not yet known.

1. ....

....

2. ....

.... **[2]**

8 **(a)** Describe a thought experiment to illustrate time dilation.

....

....

....

....

....

....

....

.... **[4]**

(b) The time dilation equation may be written as

$$t = \frac{t_0}{\sqrt{(1 - v^2/c^2)}} .$$

(i) Explain what the symbols t_0 and t in this equation represent.

....

....

.... **[1]**

(ii) Muons are sub-atomic particles having, when at rest, a half-life of 1.52 μs. Such particles, created in the upper atmosphere, travel towards the Earth's surface at a speed approximately equal to that of light.

A muon detector, suspended from a balloon at an altitude of 1830 m, detects 4830 muons in 10 minutes. A similar detector at sea level, vertically below the balloon, detects 2710 muons in the same interval of time.

1. Assuming that the muons travel at the speed of light, calculate the time of travel between the two detectors, as measured by a person on Earth.

time = ...μs **[2]**

2. Using your answer to **1**, and assuming that fast-moving muons also have a half-life of 1.52 μs, calculate the number of muons which would be expected at the sea-level detector in the ten-minute period.

number = ... **[3]**

3. By reference to the actual number detected, comment on your answer to **2**.

....

....

....

....
[1]

9 The path of light can be affected by gravitational forces. Explain how a stellar object may therefore produce two visible images at the same time.

....

....

....

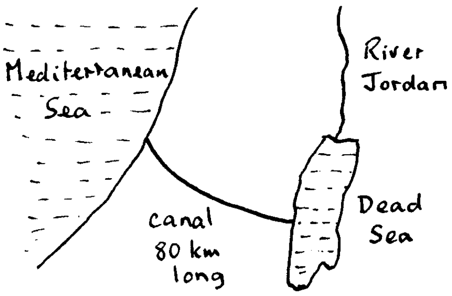
.... **[3]**

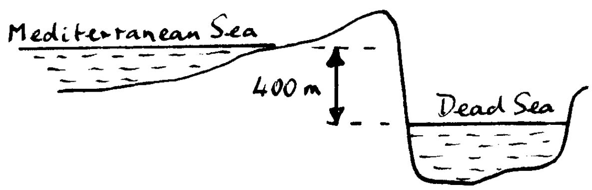
10 The following paragraph is based on a scientific article.

The World Bank is considering the construction of a vast hydroelectric project to bring fresh water to Israel, Jordan and Palestine. The project would involve building a canal from the Mediterranean Sea to the Dead Sea, which lies 400 m below sea level. The canal would have hydroelectric plants to generate electricity for desalination plants at intervals along its length. The desalination plants could produce up to 100 million cubic metres of fresh water per year. At present the Dead Sea is fed by the river Jordan, but there has been so much extraction of water for drinking and irrigation that in summer the flow of the river has been reduced to little more than a muddy trickle. The Dead Sea, the salinity of which makes it the densest body of water on Earth, is prone to rapid evaporation and, as more water has been tapped, the level has fallen by 3.0 metres in the last 35 years. The canal project would be a way of stopping this decline.

In carrying out detailed studies on the project, engineers have the following additional geographical and physical data.

Surface area of the Dead Sea	880 km^2
Energy required to vaporise 1 kg of water	2.3×10^6 J
Mean power absorbed by water from sunlight during daylight	300 W m^{-2}
Acceleration of free fall	9.8 m s^{-2}
Density of sea water in Mediterranean Sea	1030 kg m^{-3}





Answer the following questions about this project using the data supplied.

(a) What reason does the passage suggest for the Dead Sea being the 'densest body of water on Earth'?

....

.... **[1]**

(b) Calculate the power absorbed by the Dead Sea from the Sun during daylight.

power = ...W **[2]**

(c) If 60% of the power calculated in (b) is used to evaporate water from the Dead Sea, calculate the mass of water which evaporates in 12 hours of daylight.

mass = ... kg **[3]**

(d) Using the overall fall of the level of the Dead Sea, estimate the change during the last 35 years in the mass of water in the Dead Sea.

mass = ... kg **[3]**

(e) As the water falls from the Mediterranean Sea into the Dead Sea it loses one form of energy. What form of energy is this?

.... **[1]**

(f) Assume that the proposed project aims to refill the Dead Sea to its former level in the next 35 years. Estimate the power available from the water falling from the Mediterranean Sea into the Dead Sea.

power = ... W **[4]**

(g) A desalination plant operates on a cycle by evaporating water vapour from sea water and then condensing the water vapour back into fresh water. Explain why less than 2.3 x 106 joules are needed for each kilogram of fresh water produced in the cycle

....

....

....

.... **[2]**

(h) State and explain two physical problems which will make the scheme less efficient than indicated in **(f)**.

1. ....

....

....

....

2. ....

....

....

....
[4]

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

COSMOLOGY **2825/01**

Mark Scheme

1	**(a)**	radius of orbit drawn		B1	
	(b)	$2 / n$ or $1 / n$		M1	
		2 factor correct		A1	**[3]**
2	**(a)**	$m_C - m_R = 2.5(\lg I_R - \lg I_C)$		M1	
		$1.2 = 2.5 \lg (I_R / I_C)$		A1	
		leading to $I_R / I_C = 3.02$		A0	**[2]**
	(b)	**(i)**	$m - M = 5 \lg (r / 10)$	B1	
		(ii)	$0.3 - (-7.5) = 5 \lg(r / 10)$	C1	
			$r = 363$ pc	A1	**[3]**
3	**(a)**	**(i)**	*y*-axis: brightness and direction	B1	
			x-axis: temperature and direction	B1	
		(ii)	on Main Sequence	M1	
			in lower right-hand section	A1	
		(iii)	Main Sequence	B1	**[5]**
	(b)	**(i)**	red giant	M1	
			with location correct	A1	
			white dwarf	M1	
			with location correct	A1	
		(ii)	from S to red giant	B1	
			then cross the Main Sequence to white dwarf	B1	**[6]**
	(c)	dark		B1	
		cold body		B1	**[2]**
4	**(a)**	$T^2 \propto d^3$		M1	
		T and *d* explained		A1	
		for circular orbits		B1	**[3]**
	(b)	**(i)**	If $T = kd^n$ }		
			taking logs, $\lg T = \lg k + n \lg d$ }	M1	
			n is gradient of graph	A1	**[2]**
		(ii)	graph: axes labelled and scale	B1	
			correct plots *(-1 each error or omission)*	B2	**[3]**
		(iii)	suitable triangle	B1	
			finds gradient correctly	B1	
			conclusion	B1	**[3]**
		(iv)	e.g. may be elliptical what does *d* mean? graph does not allow constant (if any) to be determined i.e. $T = a + kd^n$ *(1 mark each, max. 2)*	B2	**[2]**

5	**(a)**	Infinite Universe	B1	
		Static Universe	B1	**[2]**
	(b)	night sky as bright as day sky	M1	
		because every line of sight ends in a star	A1	
		there would hence be time for light to arrive	A1	
		because static	A1	**[4]**
6	**(a)**	**(i)** $\Delta l \,/\, l = v\,/\,c$	B1	
		(ii) $l \approx 425$ nm	B1	
		$\Delta l \approx 200$ nm	B1	
		speed = 1.4×10^{8} m s^{-1}	A1	
		away from observer	A1	**[5]**
	(b)	would have to be moving towards Earth	B1	
		perhaps on edge of galaxy	B1	
		speed would be enormous, so unlikely	B1	**[3]**
	(c)	**(i)** expanding	B1	
		(ii) galaxies all moving away from one another	B1	
		with speed dependent on distance $v = H_0 d$	B1	**[3]**
7	**(a)**	Universe will stop expanding but not contract again	B1	**[1]**
	(b)	**(i)** correct curve labelled	B1	
		(ii) P labelled correctly	B1	**[2]**
	(c)	e.g. amount of matter in Universe unknown size of Universe not known *(l each, max. 2)*	B2	**[2]**
8	**(a)**	diagram showing relative motion	B1	
		event occupying time interval specified	B1	
		both observers measure same time interval	B1	
		'moving' clock slower because longer path {and c is constant}	B1	**[4]**
	(b)	**(i)** t_0 time observer at rest, t is same time for 'external' observer	B1	**[1]**
		(ii) 1. time = $1830 / 3.0 \times 10^{8}$	C1	
		= 6.1 μs	A1	
		2. approximately 4 half-lives	C1	
		so 2^4 fewer	C1	
		hence 302 in 10 minutes	A1	
		(allow 'long-winded' method)		
		3. half-life extended	B1	**[6]**
9		large mass in line between observer and stellar object	B1	
		attraction of light by large body	B1	
		diagram to illustrate	B1	**[3]**

10	**(a)**	prone to rapid evaporation	B1	**[1]**
	(b)	880 km^2 = 880 x 10^6 m^2	C1	
		power = 880 x 10^6 x 300		
		= 2.64 x 10^{11} W	A1	**[2]**
	(c)	$E = \Delta m.L$	C1	
		E = 0.60 x 2.64 x 10^{11} x 12 x 3600	C1	
		= 6.84 x 10^{15} J		
		m = (6.84 x 10^{15}) / (2.26 x 10^6)		
		= 3.03 x 10^9 kg	A1	**[3]**
	(d)	volume lost = 880 x 10^6 x 3	C1	
		= 2.64 x 10^9 m^3		
		mass = 2.64 x 10^9 x 1030	C1	
		= 2.7 x 10^{12} kg	A1	**[3]**
	(e)	(gravitational) potential energy	B1	**[1]**
	(f)	mass which can enter in next 35 years		
		= 2 x 2.7 x 10^{12} kg B1		
		power = mgh / t	C1	
		= (5.4 x 10^{12} x 9.8 x 400) / (35 x 365 x 86400) C1		
		= 19.2 MW	A1	**[4]**
	(g)	heat required to produce evaporation	B1	
		can be recovered when steam condenses	B1	**[2]**
	(h)	e.g. 1. water will evaporate from system so less potential energy available		
		2. water in canal has kinetic energy so less energy available for conversion		
		statement, 1 each	*B*2	
		explanation, 1 each	B2	**[4]**

COSMOLOGY

ASSESSMENT GRID

Question Number	Learning Outcome	AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a)	1 (i)		1			1	
(b)	1 (i)	1	1			2	3
2 (a)	2 (h) (d)	2				2	
(b) (i)	2 (g)	1					
(b) (ii)	2 (g)	2				3	5
3 (a) (i)	2 (h)	1	1				
(a) (ii)	2 (h)	1	1				
(a) (iii)	2 (h)	1				5	
(b) (i)	2 (j)	2	2				
(b) (ii)	2 (k)	1	1			6	
(c)	2 (k)	1	1			2	13
4 (a)	3 (d)	3				3	
(b)	synoptic				10	10	13
5 (a)	3 (b)	2				2	
(b)	3 (a) (b)	2	2			4	6
6 (a) (i)	4 (e)	1					
(a) (ii)	4 (e) (f)	1	3			5	
(b)	4 (f)		3			3	
(c) (i)	4 (f)	1					
(c) (ii)	3 (d)	2				3	11
7 (a)	5 (g)	1				1	
(b)	5 (g)		2			2	
(c)	5 (e) (f) (g)		2			2	5
8 (a)	6 (b)	4				4	
(b) (i)	6 (e)	1				1	
(b) (ii)	6 (c)	2	4			6	11
9	6 (j)	1	2			3	3
10	Synoptic				20	20	20
		30	30		30	90	90

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

HEALTH PHYSICS **2825/02**

Specimen Paper

Candidates answer on the question paper.
Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Questions 4 and 8 are synoptic in nature. In response to these questions, you are encouraged to bring together principles and concepts of physics to show comprehension, and to use skills of physics in the analysis of data.

Data

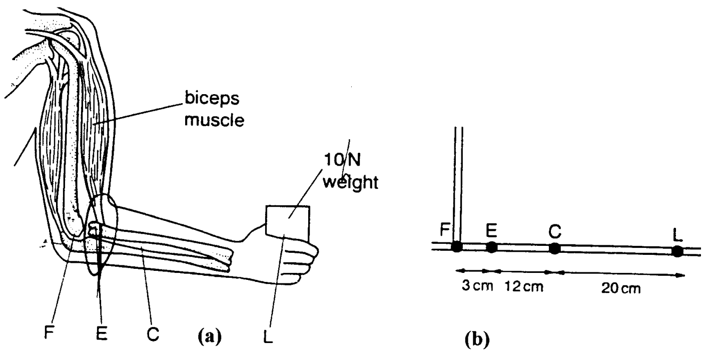
speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$m_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$e_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
drag force,	$F = \frac{1}{2}AC_D r v^2$
lift force in streamline flow,	$F = \frac{1}{2}SC_L rv^2$
refractive index,	$n = 1 / \sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0 \, e^{-t/CR}$
pressure of an ideal gas,	$p = Nm\langle c^2 \rangle / 3V$
radioactive decay,	$x = x_0 \, e^{-mt}$,
	$l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^2 / 8\pi G$
relativity factor,	$\gamma = \sqrt{\{1 - v^2/c^2\}}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$

Answer **all** the questions in the spaces provided

1 **(a)** Fig. 1.1(a) illustrates some muscles and bones in the arm. C is the position of the centre of gravity of the lower arm, including the hand. Fig. 1.1(b) shows the relevant distances.



(a) **(b)**

Fig. 1.1

(i) On Fig. 1.1(b), draw labelled arrows to represent the force exerted by the biceps muscle, the weight of the lower arm, and the 10 N weight in the hand, acting through the point L. **[3]**

(ii) The weight of the lower arm, including the hand is 15 N. Show that the force exerted by the biceps muscle to maintain the lower arm in this position is approximately 190 N.

[4]

(b) The force exerted by the biceps muscle is much greater than the size of the load. Suggest what advantage is derived from this lever system.

....

....

[2]

2 **(a)** **(i)** State, with reference to the eye, what is meant by *accommodation*.

....

[2]

(ii) Explain how accommodation is achieved in the human eye.

....

....

.... **[2]**

(b) An eye has a total power of 59 D when viewing a distant object. For the following calculations, assume that the focusing system of the eye is a single lens situated at the front of the eye.

(i) Show that the distance from this lens to the retina is 1.7 cm.

[2]

(ii) Calculate the focal length, of the focusing system when viewing an object 35 cm in front of the eye,

focal length = ...cm **[3]**

3 Fig. 3.1 illustrates the variation with frequency of the minimum intensity of sound detectable by a young person with normal hearing.

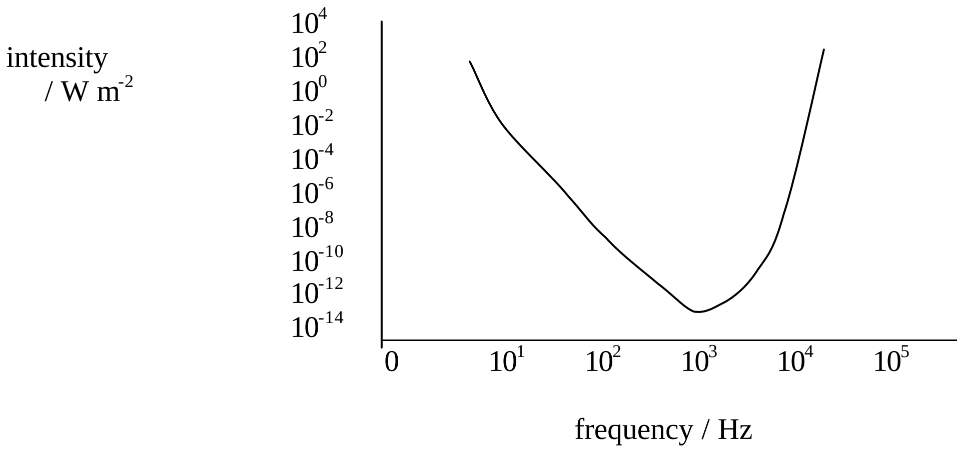


Fig. 3.1

(a) **(i)** On Fig. 3.1, shade an area to show where sound would be detected by the ear of the young person. **[1]**

(ii) Use Fig. 3.1 to find

1. the threshold intensity I0,

I0 = ...W m^{-2} **[1]**

2. the frequency at which the ear is most sensitive.

frequency = ... Hz **[2]**

(b) Explain what is meant by the *logarithmic response* of the ear to sound intensity.

....

....

....

....

.... **[4]**

(c) The sound intensity measured in one part of a factory is 3.2 x 10-2 W m^{-2}. For health reasons, it is necessary to reduce the sound intensity incident on the ears of the workers to 3.2 x 10^{-5} W m^{-2}. This is achieved by using ear defenders.
Calculate

(i) the intensity level of sound in that part of the factory,

intensity level =........................... **[3]**

(ii) the reduction in intensity level which must be achieved by the ear defenders.

reduction = ... **[2]**

4 Measurements of the intensity I of a collimated X-ray beam for different thicknesses x of a medium was measured. The results are given in Fig. 4.1 together with values for ln I.

x / m	I / W m^{-2}	ln (I / W m^{-2})
0	8.30	2.116
0.040	6.15	.816
0.060	5.32	1.671
0.080	4.60	1.526
0.100	3.96	1.376
0.120	3.44	1.235
0.140	2.96	1.085
0.160	2.51	0.920

Fig. 4.1

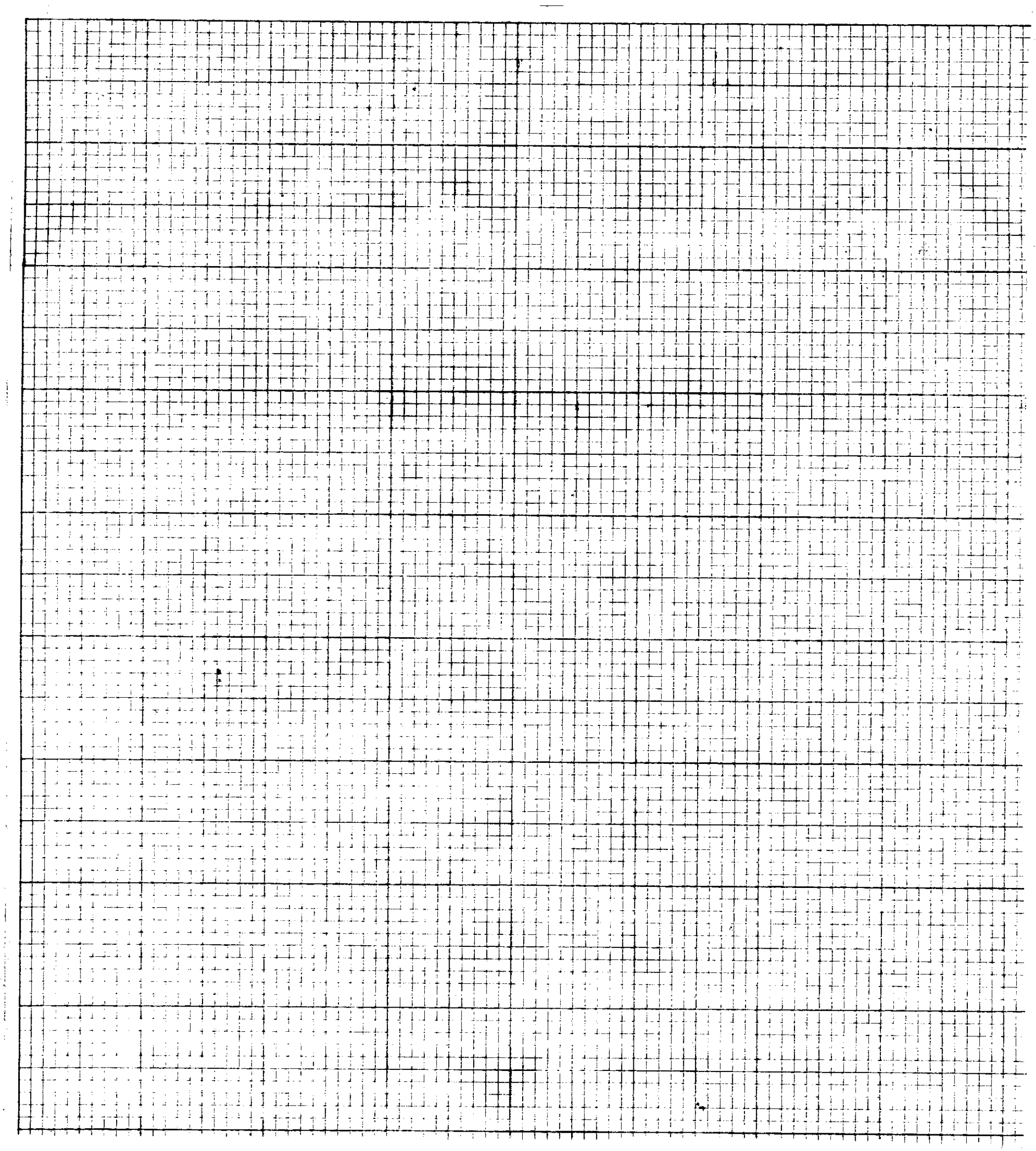
(a) Explain why one extra significant figure is justified when calculating the natural logarithm.

....

....

.... **[2]**

(b) On Fig. 4.2, plot a graph of ln I (vertical axis) against x (horizontal axis).



[2]

Fig. 4.2

(c) The equation of the line drawn in (b) is $\ln I = \ln I_0 - mx$

Use your graph to determine I_0 and m.

I_0=....................................

m = ... **[4]**

(d) Deduce the thickness of the medium which halves the X-ray intensity.

thickness = ...m. **[2]**

5 **(a)** Outline the principles of the production of ultrasound.

....

....

....

....

....

.... **[5]**

(b) Fig. 5.1 gives information relating to ultrasound in muscle and fat.

tissue	density/ kg m^{-3}	Speed of ultrasound/ m s^{-1}	acoustic impedance / kg m^{-2} s^{-1}
muscle	1.1×10^3	1.6×10^3	....
fat	0.9×10^3	1.5×10^3	....

Fig. 5.1

The acoustic impedance Z of a medium is given in terms of its density r and the speed c of ultrasound in the medium by the expression

$$Z = rc.$$

(i) Complete Fig. 5.1 by calculating the acoustic impedance of muscle and of fat. **[2]**

(ii) Hence suggest whether an echo could be expected from a fat-muscle boundary.

....

.... **[2]**

(c) Explain why a coupling medium is required between the transducer and the skin of a patient when conducting ultrasound diagnosis.

....

....

....

.... **[4]**

(d) An ultrasound pulse travels through fat and is detected after reflection at a fat/tissue boundary. The time interval between the pulse being emitted into the layer of fat and received back at the transducer is 0.017 ms. Use the information from Fig. 5.1 in order to calculate the thickness of the layer of fat.

thickness = ... m **[3]**

6 **(a)** State what is meant by radiation exposure and absorbed dose.

exposure...

absorbed dose ....

.... **[4]**

(b) Explain why, for the same absorbed dose, the dose equivalent would be different for exposure to a-particles than for exposure to g-radiation.

....

....

.... **[3]**

7 **(a)** The use of a conventional scalpel for the removal of a portion of diseased liver from a live patient is inadvisable because of the risks of haemorrhaging. However, the use of a laser as a scalpel reduces these risks.
Explain why a laser is suitable for use as a scalpel in this type of surgery.

....

....

.... **[3]**

(b) Fig. 7.1 illustrates laser light being used to destroy unhealthy tissue.

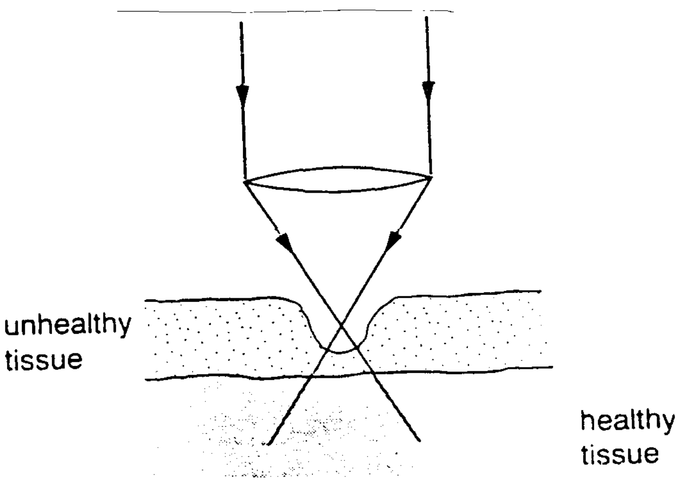


Fig. 7.1

Suggest why only some tissue in the laser beam is destroyed.

....

....

.... **[3]**

8 The following paragraph is based on a scientific article.

The World Bank is considering the construction of a vast hydroelectric project to bring fresh water to Israel, Jordan and Palestine. The project would involve building a canal from the Mediterranean Sea to the Dead Sea, which lies 400 m below sea level. The canal would have hydroelectric plants to generate electricity for desalination plants at intervals along its length. The desalination plants could produce up to 100 million cubic metres of fresh water per year. At present the Dead Sea is fed by the river Jordan, but there has been so much extraction of water for drinking and irrigation that in summer the flow of the river has been reduced to little more than a muddy trickle. The Dead Sea, the salinity of which makes it the densest body of water on Earth, is prone to rapid evaporation and, as more water has been tapped, the level has fallen by 3.0 metres in the last 35 years. The canal project would be a way of stopping this decline.

In carrying out detailed studies on the project, engineers have the following additional geographical and physical data.

Surface area of the Dead Sea	880 km^2
Energy required to vaporise 1 kg of water	2.3×10^6 J
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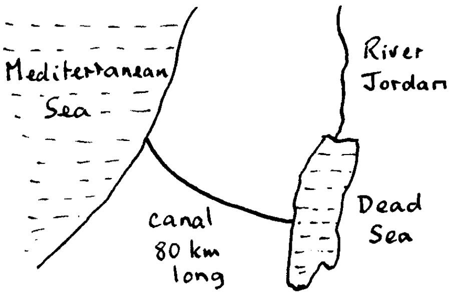
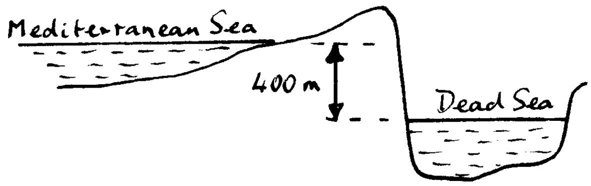




Answer the following questions about this project using the data supplied.

(a) What reason does the passage suggest for the Dead Sea being the 'densest body of water on Earth'?

....

.... **[1]**

(b) Calculate the power absorbed by the Dead Sea from the Sun during daylight.

power = ...W **[2]**

(c) If 60% of the power calculated in (b) is used to evaporate water from the Dead Sea, calculate the mass of water which evaporates in 12 hours of daylight.

mass = ... kg **[3]**

(d) Using the overall fall of the level of the Dead Sea, estimate the change during the last 35 years in the mass of water in the Dead Sea.

mass = ... kg **[3]**

(e) As the water falls from the Mediterranean Sea into the Dead Sea it loses one form of energy. What form of energy is this?

.... **[1]**

(f) Assume that the proposed project aims to refill the Dead Sea to its former level in the next 35 years. Estimate the power available from the water falling from the Mediterranean Sea into the Dead Sea.

power = ... W **[4]**

(g) A desalination plant operates on a cycle by evaporating water vapour from sea water and then condensing the water vapour back into fresh water. Explain why less than 2.3 x 106 joules are needed for each kilogram of fresh water produced in the cycle.

....

....

....

.... **[2]**

(h) State and explain two physical problems which will make the scheme less efficient than indicated in **(f)**.

1. ....

....

....

....

....

2. ....

....

....

....

....

....

[4]

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

HEALTH PHYSICS **2825/02**

Mark Scheme

1	**(a)**	**(i)**	diagram: all three arrows correct	B3	**[3]**
		(ii)	Moments about F	C1	
			(B x 3) = (15 x 15) + (10 x 35) *(-1 for each error)*	M2	
			3B = 225 + 350 = 575	A1	
			B = 192 N	A0	**[4]**
	(b)		small movement of muscle	B1	
			gives large movement of load	B1	**[2]**
2	**(a)**	**(i)**	ability to focus images formed from objects at different distances from the eye	B1	
		(ii)	ciliary muscles	B1	
			alter the thickness of the lens	B1	
			thin for focusing distant objects, thick for near objects	B1	**[4]**
	(b)	**(i)**	for object at infinity $v = f$	B1	
			$f = 1 / D = 1 / 59 = 0.017$ m	M1	
			$\therefore v = 0.017\text{m} = 1.7$ cm	A0	**[2]**
		(ii)	$1/u + 1/v = 1/f$	C1	
			$1/35 + 1/v = 1/f$ and v is still 1.7 cm	C1	
			focal length = 1.62 cm	A1	**[3]**
3	**(a)**	**(i)**	diagram: shading correct	B1	
		(ii)	1. $I_0 = 1.0 \times 10^{-12}$ W m^{-2}	B1	
			2. $\lg f = 3.6 \pm 0.05$ (by careful measurement)	C1	
			$f = 4.0 \times 10^3$ Hz	A1	**[4]**
			(Allow l mark for $(6 \pm 1.5) \times 10^3$ Hz)		
	(b)		e.g. loudness is the response of ear to intensity	B1	
			change in loudness depends on fractional change in intensity	M1	
			so use intensity level as lg (I/I_0)	A1	
			small change in loudness detectable at low loudness level OR large change in loudness needed at high loudness level	B1	**[4]**
	(c)	**(i)**	intensity level = 10 lg (I/I_0)	C1	
			= 10 lg (3.2×10^{-5} / 10^{-12})	C1	
			= 105 dB	A1	
		(ii)	new intensity level = 75 dB	C1	
			reduction = 30 dB	A1	**[5]**
4	**(a)**		The first figure of a logarithm is the power to which e must be raised	B1	
			The 3 sig. figs. are therefore after the decimal point	B1	**[2]**

	(b)	graph: axes	B1	
		points plotted correctly *(-1 each error or omission)*	B1	
		straight line	B0	**[2]**
	(c)	ln I_0 = 2.12	C1	
		I_0 = 8.3(3) W m^{-2}	A1	
		m = - slope	C1	
		= 7.5 m^{-1}	A1	**[4]**
	(d)	ln I falls by 0.693	C1	
		e.g. 1.693 to 1.000		
		(0.0580) to (0.1495)		
		thickness = 0.092 m	A1	**[2]**
5	**(a)**	use a piezo-electric crystal	B1	
		apply p.d. across it and its shape changes	B1	
		alternating p.d. causes oscillations	B1	
		crystal cut to produce resonance at frequency of applied p.d.	B1	
		any other valid point e.g. frequency used	B1	**[5]**
	(b)	(i) muscle: 1.76×10^6	B1	
		fat: 1.35×10^6	B1	
		(ii) Yes	M1	
		because for reflection acoustic impedance must be different	A1	**[4]**
	(c)	acoustic impedance of air is very low	B1	
		so all ultrasound would be reflected at air/skin	B1	
		coupling medium has same acoustic impedance	B1	
		as skin and transducer	B1	**[4]**
	(d)	$s = vt = 0.017 \times 10^{-3} \times 1.5 \times 10^3$	C1	
		= 2.55 cm	C1	
		thickness = ½ x 2.55 = 1.3 cm	A1	**[3]**
6	**(a)**	exposure: measure of radiation energy	M1	
		incident on the body	A1	
		absorbed dose: measure of energy per unit mass	M1	
		absorbed by the body	A1	
		(idea of incident and absorbed scores 1 mark if all else fails)		**[4]**
	(b)	dose equivalent = dose x quality factor	B1	
		factor depends on density of ionisation	B1	
		which is greater for α than for γ	B1	**[3]**

7	**(a)**	laser reduces damage to blood vessels cauterises the wound laser vaporises water from cells *(or any other valid points to max. 3)*	B1 B1 B1	**[3]**
	(b)	intensity varies in focused beam need minimum intensity to destroy tissue only high enough close to focus	B1 B1 B1	**[3]**
8	**(a)**	prone to rapid evaporation	B1	**[1]**
	(b)	880 km^2 = 880 x 10^6 m^2 power = 880 x 10^6 x 300 = 2.64 x 10^{11} W	C1 A1	**[2]**
	(c)	$E = \Delta m.L$ = 0.60 x 2.64 x 10^{11} x 12 x 3600 = 6.84 x 10^{15} J m = (6.84 x 10^{15}) / (2.26 x 10^6) = 3.03 x 10^9 kg	C1 C1 A1	**[3]**
	(d)	volume lost = 880 x 10^6 x 3 = 2.64 x 10^9 m^3 mass = 2.64 x 10^9 x 1030 = 2.7 x 10^{12} kg	C1 C1 A1	**[3]**
	(e)	(gravitational) potential energy	B1	**[1]**
	(f)	mass which can enter in next 35 years = 2 x 2.7 x 10^{12} kg power = mgh / t = (5.4 x 10^{12} x 9.8 x 400) / (35 x 365 x 86400) = 19.2 MW	 B1 C1 C1 A1	**[4]**
	(g)	heat required to produce evaporation can be recovered when steam condenses	B1 B1	**[2]**
	(h)	e.g. 1. water will evaporate from system so less potential energy available 2. water in canal has kinetic energy so less energy available for hydroelectric scheme Statement, 1 each Explanation, 1 each	 B2 B2	**[4]**

HEALTH PHYSICS

ASSESSMENT GRID

Question Number	Learning Outcome	AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a) (i)	1 (a) (c)		3			3	
(a) (ii)	1 (b)	2	2			4	
(b)	1 (b)	1	1			2	9
2 (a) (i)	2 (n)	1					
(a) (ii)	2 (k) (n)	3				4	
(b) (i)	2 (o)		2			2	
(b) (ii)	2 (l)		3			3	9
3 (a)	3 (c)	2	2			4	
(b)	3 (e) (f)	2	2			4	
(c)	3 (f)	1	4			5	13
4	synoptic				10	10	10
5 (a)	4 (f)	3	2			5	
(b) (i)	4 (h)		2				
(b) (ii)	4 (g)	1	1			4	
(c)	4 (l)	4				4	
(d)	4 (g)		3			3	16
6 (a)	5 (c) (d)	4				4	
(b)	5 (f) (g)	3				3	7
7 (a)	5 (k)	2	1			3	
(b)	5 (j)	1	2			3	6
8	Synoptic				20	20	20
		30	30		30	90	90

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

MATERIALS **2825/03**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Questions 5(d) and 7 are synoptic in nature. In response to these questions, you are encouraged to bring together principles and concepts of physics to show comprehension, and to use skills of physics in the analysis of data.

Data

speed of light in free space,	$c = 3.00 \text{ x } 10^{8}$ m s^{-1}
permeability of free space,	$m_0 = 4\pi \text{ x } 10^{-7}$ H m^{-1}
permittivity of free space,	$e_0 = 8.85 \text{ x } 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \text{ x } 10^{-19}$ C
the Planck constant,	$h = 6.63 \text{ x } 10^{-34}$ J s
unified atomic mass constant,	$u = 1.67 \text{ x } 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \text{ x } 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \text{ x } 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \text{ x } 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \text{ x } 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + ½at^2$ $v^2 = u^2 + 2as$
refractive index,	$n = 1/\sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0 \, e^{-t/CR}$
pressure of an ideal gas,	$p = Nm<c^2> / 3V$
radioactive decay,	$x = x_0 \, e^{-mt}$ $l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^2 / 8\pi G$
relativity factor,	$g = \sqrt{\{1 - v^2/c^2\}}$
sound intensity level,	$I.L. = 10 \lg(I/I_0)$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$

Answer **all** the questions in the spaces provided.

1 **(a)** Draw diagrams to illustrate the following the following close-packed structures.

(i) face-centred cubic

[2]

(ii) hexagonal close-packed

[2]

(b) Explain the difference between these two structures in terms of the stacking of the layers of atoms.

....

....

....

.... **[2]**

2 Fig. 2.1 illustrates the variation with the separation x of the resultant force F between two atoms. The two atoms are neighbouring atoms in a pure metal wire of area of cross-section 6.8×10^{-7} m^2.

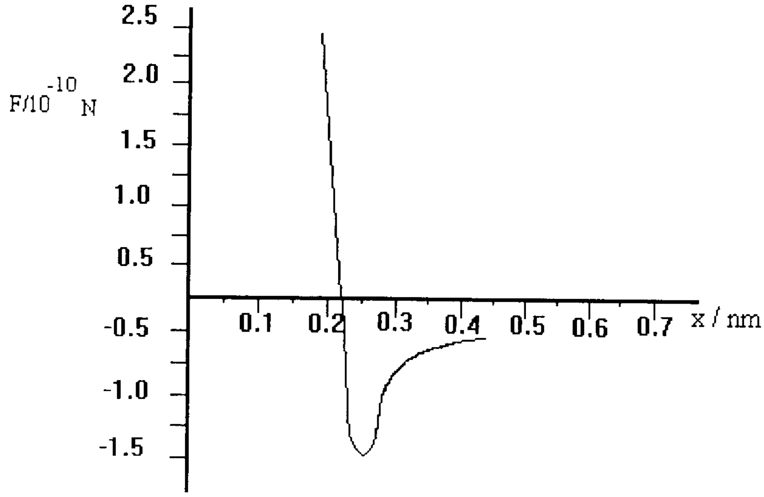


Fig. 2.1

(a) With reference to Fig. 2.1, state

(i) the range of values of x over which the resultant force is attractive,

.... **[1]**

(ii) the value of x for equilibrium separation.

x = ... nm

[1]

(b) **(i)** State the value of the maximum attractive force F_{max} between two neighbouring atoms.

F_{max} =.............................. N **[1]**

(ii) State the spacing x_F between the atoms for this maximum force.

x_F = ... nm **[1]**

(iii) Making the assumption that all the atoms in the material have the spacing in **(ii)**, calculate

1. the number of atoms in a layer of area 6.8×10^{-7} m^2,

number of atoms = ...

2. the theoretical maximum breaking force of the wire of area of cross-section 6.8×10^{-7} m^2.

breaking force = ... N

[4]

(iv) Give two reasons why your answer in (iii) is far larger than is ever achieved in practice.

1. ....

....

2. ....

.... **[2]**

3 (a) (i) Define *electrical conductivity.*

....

.... **[1]**

(ii) A 100 m length of copper wire which has an area of cross-section 0.111 mm^2 has resistance 15.5 Ω. Calculate the conductivity of copper.

conductivity ....**[3]**

(b) The wire in **(a)** has a current of 0.62 A passing through it. Calculate the magnitude of the drift velocity of the free electrons in the wire, given that the concentration of free electrons in copper is 8.7×10^{28} m^{-3}.

drift velocity = ... $m\ s^{-1}$ **[3]**

(c) In a metal, free electrons move at speeds of up to 10^6 $m\ s^{-1}$. Comment on the difference between this value and the value calculated for the drift velocity in **(b)**.

....

....

....

.... **[2]**

4 **(a)** Fig. 4.1 illustrates two energy level bands in a semiconductor material.

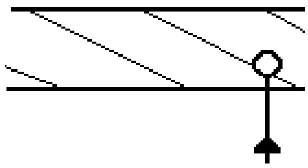


Fig. 4.1

An electron transition takes place from the lower energy band to the higher.

(i) On Fig. 4.1, label the conduction band and the valence band. **[2]**

(ii) State a possible situation in which the electron transition is more likely to occur.

....

.... **[1]**

(iii) State how such transitions affect the resistance of the semiconductor material.

....

[1]

(b) Fig. 4.2 illustrates the variation with temperature of the resistance of a sample of mercury.

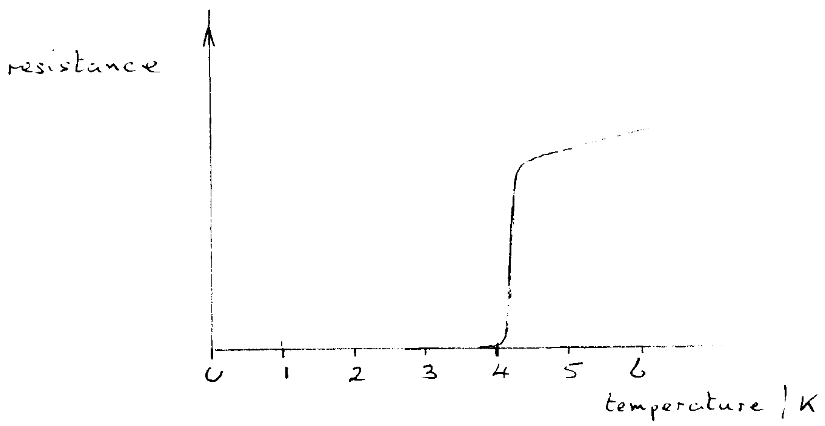


Fig. 4.2

Describe the changes in the resistance of mercury as its temperature decreases from 4.3K to 4.0K.

....

....

.... **[2]**

(c) Outline briefly details of a practical use of materials which show behaviour similar to that illustrated in Fig. 4.2.

....

....

....

.... **[2]**

5 **(a)** **(i)** State what is meant by a *magnetic domain*.

....

.... **[2]**

(ii) With reference to the domain theory of magnetism, distinguish between hard and soft ferromagnetic materials.

....

....

.... **[1]**

(b) State what is meant by *magnetic saturation*.

....

.... **[1]**

(c) Fig. 5.1(a) illustrates the magnetic hysteresis loop for a magnetic material suitable for use as the core of a transformer.

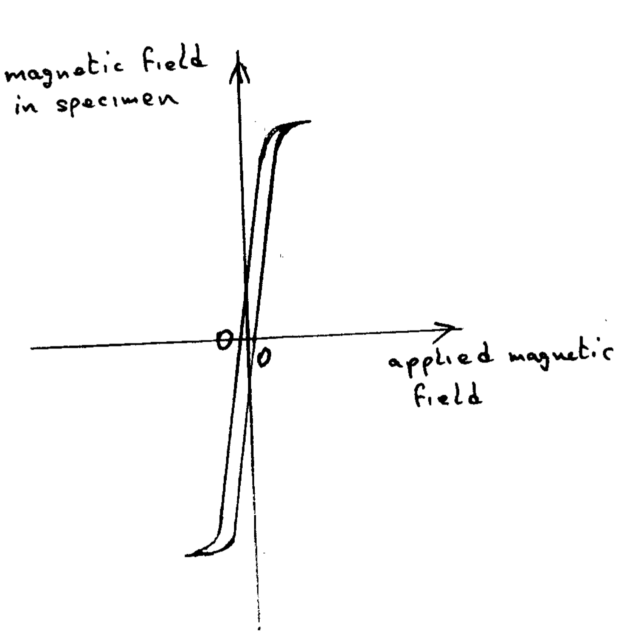


Fig. 5.1(a)

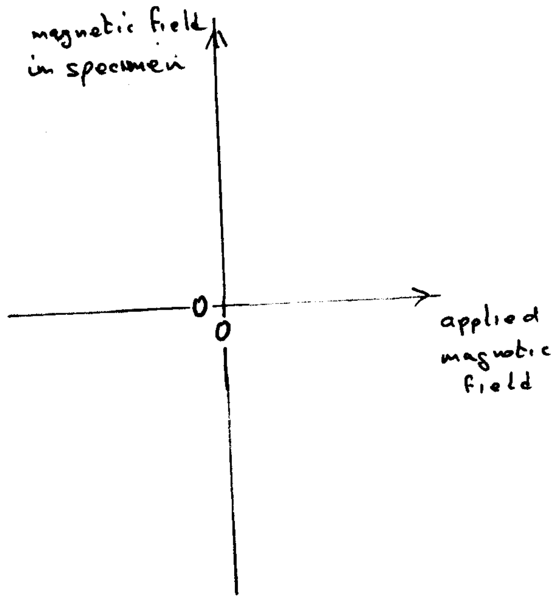


Fig. 5.1(b)

(i) On Fig. 5.1(a), label the axes. **[1]**

(ii) State the significance of the shaded area on Fig. 5.1(a).

....

.... **[1]**

(iii) On the axes of Fig. 5.1(b), and using the same scales as in Fig. 5.1(a), draw a magnetic hysteresis loop for a ferromagnetic material unsuitable for the use as the core of a transformer. **[2]**

(d) Table 5.2 shows data for the variation with input current I_I of the resistive power losses P_R in the coils of a large transformer. The maximum input current is 50 A at a p.d. of 11000 V.

I_I / A	P_R / W	lg(I_I / A)	lg(P_R / W)
10	180	1.000	2.255
20	720	1.301	2.857
30	1610	1.477	3.207
40	2900		
50	4500		

Table 5.2

(i) Complete Table 5.2 **[2]**

(ii) Plot a graph of lg P_R against lg I_I. **[3]**

(iii) Use your graph to find the mathematical relationship between P_R and I_I, given that it is of the form

$$P_R = k\ I_i^n.$$

relationship .... **[5]**

6 **(a)** Explain, using band theory, why insulators can be transparent to visible light and metals are opaque to visible light.

....

....

....

....

....

....

.... **[4]**

(b) **(i)** State the conditions under which Rayleigh scattering occurs in glass.

....

.... **[2]**

(ii) Explain why red light is scattered less than blue light.

....

....

....

.... **[3]**

(iii) Use the information given in **(ii)** to suggest why sunsets are red and the sky is blue.

....

....

.... **[2]**

(c) The transmission of signals over large distances along an optic fibre is possible because high purity glass can be manufactured.

(i) State two processes which reduce the intensity of the transmitted signal.

1. ....

2. .... **[2]**

(ii) Suggest why the electromagnetic radiation used in optic fibres is usually infra-red rather than visible.

....

....

.... **[2]**

(iii) State two advantages and two disadvantages of lasers compared with light-emitting diodes (LEDs) for the generation of signals to be transmitted along optic fibres.

....

....

....

....

....

.... **[4]**

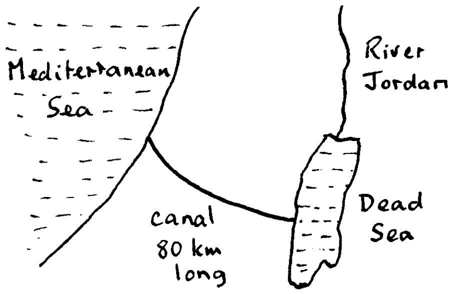
7 The following paragraph is based on a scientific article.

The World Bank is considering the construction of a vast hydroelectric project to bring fresh water to Israel, Jordan and Palestine. The project would involve building a canal from the Mediterranean Sea to the Dead Sea, which lies 400 m below sea level. The canal would have hydroelectric plants to generate electricity for desalination plants at intervals along its length.

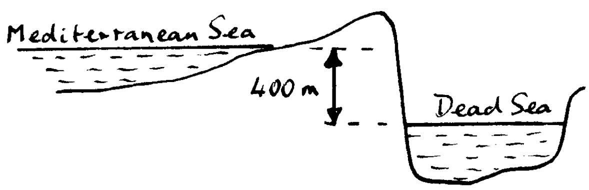
The desalination plants could produce up to 100 million cubic meters of fresh water per year. At present the Dead Sea is fed by the river Jordan, but there has been so much extraction of water for drinking and irrigation that in summer the flow of the river has been reduced to little more than a muddy trickle. The Dead Sea, the salinity of which makes it the densest body of water on Earth, is prone to rapid evaporation and, as more water has been tapped, the level has fallen by 3.0 meters in the last 35 years. The canal project would be a way of stopping this decline.

In carrying out detailed studies on the project, engineers have the following additional geographical and physical data.

Surface area of the Dead Sea	880 km^2
Energy required to vaporise 1 kg of water	2.3×10^6 J
Mean power absorbed by water from sunlight during daylight	300 W m^{-2}
Acceleration of free fall	9.8 m s^{-2}
Density of sea water in the Mediterranean Sea	1030 kg m^{-3}



Sketch map of area



Cross-section

Answer the following questions about this project using the data supplied.

(a) What reason does the passage suggest for the Dead Sea being the 'densest body of water on Earth'?

....

.... **[1]**

(b) Calculate the power absorbed by the Dead Sea from the Sun during daylight.

power = ... W **[2]**

(c) If 60% of the power calculated in (b) is used to evaporate water from the Dead Sea, calculate the mass of water which evaporates in 12 hours of daylight.

mass = ... kg **[3]**

(d) Using the overall fall of the level of the Dead Sea, estimate the change during the last 35 years in the mass of water in the Dead Sea.

mass = ... kg **[3]**

(e) As the water falls from the Mediterranean Sea into the Dead Sea, it loses one form of energy.
What form of energy is this?

.... **[1]**

(f) Assume that the proposed project aims to refill the Dead Sea to its former level in the next 35 years.
Estimate the power available from the water falling from the Mediterranean Sea into the Dead Sea.

power = ...W **[4]**

(g) A desalination plants operates on a cycle by evaporating water vapour from sea water and then condensing the water vapour back into fresh water. Explain why less than 2.3×10^6 joules are needed for each kilogram of fresh water produced in the cycle.

....

....

.... **[2]**

(h) State and explain two physical problems which will make the scheme less efficient than indicated in **(f).**

1. ....

....

....

....

....

2. ....

....

....

....

.... **[4]**

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

MATERIALS **2825/03**

Mark Scheme

1	**(a)**	**(i)**	atoms at corners of cube	M1	
			additional atoms on faces	A1	
		(ii)	idea of hexagon	M1	
			intermediate layer	A1	**[4]**
	(b)		face centred cubic layers are ABCABC ...	B1	
			hexagonal close packed layers are ABABA...	B1	**[2]**
2	**(a)**	**(i)**	0.22 nm upwards	B1	
		(ii)	equilibrium separation = 0.22 nm	B1	**[2]**
	(b)	**(i)**	F_{max} = 1.3 x 10^{-10} N	B1	**[1]**
		(ii)	x_F = 0.25 nm	B1	**[1]**
		(iii)	1. area occupied by one atom = (0.25 x $10^{-9})^2$	C1	
			number of atoms = (6.8 x 10^{-7}) / (0.25 x $10^{-9})^2$	C1	
			= 1.09 x 10^{13}	A1	
			2. breaking force = 1.09 x 10^{13} x 1.3 x 10^{-10}		
			= 1400 N	B1	**[4]**
		(iv)	e.g. arrangement of atoms is not cubical atoms un-zipp from one another rather than all being pulled apart simultaneously microstructure affects maximum force *(1 mark each, max. 2)*	B2	**[2]**
3	**(a)**	**(i)**	conductivity is reciprocal of resistivity	B1	
		(ii)	conductivity = length / (resistance x area of X-section)	C1	
			= 100 / (15.5 x 0.111 x 10^{-6})	C1	
			= 5.8 x 10^7 Ω^{-1} m^{-1}	A1	**[4]**
	(b)		$I = nAve$	C1	
			v = 0.62 / (8.7 x 10^{28} x 0.111 x 10^{-6} x 1.6 x 10^{-19})	C1	
			= 4.0 x 10^{-4} m s^{-1}	A1	**[3]**
	(c)		electron's rapid movement is random	B1	
			drift velocity is superimposed	B1	**[2]**
4	**(a)**	**(i)**	conduction band labelled	B1	
			valence band labelled	B1	
		(ii)	e.g. at higher temperatures	B1	
		(iii)	reduces resistance	B1	**[4]**
	(b)		resistance falls suddenly at transition temperature	B1	
			becomes super-conducting	B1	**[2]**
	(c)		e.g. producing very large magnetic fields	M1	
			large currents with no heating effect	A1	**[2]**

5	**(a)**	**(i)**	region where all elementary magnets (dipoles)		
			are pointing in one direction	B1	
		(ii)	hard materials retain magnetism, soft do not	B1	
			domains aligned with difficulty in hard material,		
			alignment changes easily in soft material	B1	**[3]**
	(b)		all domains aligned	B1	**[1]**
	(c)	**(i)**	axes labelled correctly	B1	
		(ii)	work done to take specimen through cycle	B1	
		(iii)	graph: correct shape	M1	
			larger area enclosed	A1	**[4]**
	(d)	**(i)**	3rd row: $\lg I_1 = 1.602$, $\lg P_R = 3.462$	B1	
			4th row: $\lg I_1 = 1.699$, $\lg P_R = 3.653$	B1	**[2]**
		(ii)	graph: sensible scales	B1	
			points correct	B1	
			reasonable line	B1	**[3]**
		(iii)	$\lg P_R = \lg k + n \lg I_1$	B1	
			gradient is n	C1	
			gradient = 2.00 clear from graph	A1	
			method clear for finding intercept	B1	
			$k = 1.78$, so		
			$P_R = 1.78\, I_1^{2}$	A1	**[5]**
6	**(a)**		depends on absorption of photons	B1	
			insulator has full bands, large forbidden band		
			& empty conduction band	B1	
			photons not energetic enough to excite electrons	B1	
			electrons in metal absorb photons as conduction band		
			only partially filled	B1	**[4]**
	(b)	**(i)**	microscopic	B1	
			fluctuations in density	B1	**[2]**
		(ii)	longer wavelengths scattered least C1		
			scattering $\propto l^{-4}$	A1	
			red has longer wavelength	B1	**[3]**
		(iii)	red light penetrates atmosphere more easily than		
			blue so Sun appears red	B1	
			scattered blue light gives blue sky	B1	**[2]**
	(c)	**(i)**	e.g. absorption of photons		
			scattering of photons		
			(1 each, max. 2)	B2	**[2]**
		(ii)	much less scattering using infra-red	M1	
			because it has much longer wavelength	A1	**[2]**
		(iii)	LED's: cheaper		
			less complicated circuitry etc.		
			lasers: faster switching		
			greater output etc.		
			(1 mark for LED, 1 for laser and any other two)	B4	**[4]**

7	**(a)**	prone to rapid evaporation	B1	**[1]**
	(b)	880 km^2 = 880 x 10^6 m^2	C1	
		power = 880 x 10^6 x 300		
		= 2.64 x 10^{11} W	A1	**[2]**
	(c)	$E = \Delta L.m$	C1	
		= 0.60 x 2.64 x 10^{11} x 12 x 3600	C1	
		= 6.84 x 10^{15} J		
		m = (6.84 x 10^{15}) / (2.26 x 10^6)		
		= 3.03 x 10^9 kg	A1	**[3]**
	(d)	volume lost = 880 x 10^6 x 3	C1	
		= 2.64 x 10^9 m^3		
		mass = 2.64 x 10^9 x 1030	C1	
		= 2.7 x 10^{12} kg	A1	**[3]**
	(e)	(gravitational) potential energy	B1	**[1]**
	(f)	mass which can enter in next 35 years		
		= 2 x 2.7 x 10^{12} kg	B1	
		power = mgh / t	C1	
		= (5.4 x 10^{12} x 9.8 x 400) / (35 x 365 x 86400)	C1	
		= 19.2 MW	A1	**[4]**
	(g)	heat required to produce evaporation	B1	
		can be recovered when steam condenses	B1	**[2]**
	(h)	e.g. 1. water will evaporate from system so less potential energy available 2. water in canal has kinetic energy so less energy available for hydroelectric scheme		
		Statement, 1 each	B2	
		Explanation, 1 each	B2	**[4]**

MATERIALS

ASSESSMENT GRID

Question Number	Learning Outcome	AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a)	1 (c)	4				4	
(b)	1 (d)	1	1			2	6
2 (a)	1 (i)		2			2	
(b) (i)	1 (j)		1			1	
(b) (ii)	1 (b) (j)		1			1	
(b) (iii)	1 (b) (k)		4			4	
(b) (iv)	1 (l)	1	1			2	10
3 (a)	2 (a)	2	2			4	
(b)	2 (c)		3			3	
(c)	2 (b)	2				2	9
4 (a) (i)	2 (e)	2					
(a) (ii)	2 (f)		1				
(a) (iii)	2 (h)	1				4	
(b)	2 (i) (j) (k)		2			2	
(c)	2 (l)	2				2	8
5 (a) (i)	3 (a)	1					
(a) (ii)	3 (b)	2				3	
(b)	3 (c)	1				1	
(c) (i)	3 (d)	1					
(c) (ii)	3 (e)	1					
(c) (iii)	3 (f)	1	1			4	
(d)	Synoptic				10	10	18
6 (a)	4 (a) (b) (c)	2	2			4	
(b) (i)	4 (g)	2				2	
(b) (ii)	4 (h)		3			3	
(b) (iii)	4 (h)		2			2	
(c) (i)	4 (j)	2				2	
(c) (ii)	4 (j)		2			2	
(c) (iii)	4 (k) (l)	2	2			4	19
7	Synoptic				20	20	20
		30	30		30	90	90

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

NUCLEAR AND PARTICLE PHYSICS **2825/04**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation of your answers.

Write your numerical answers in the spaces provided. You must take care that the correct unit is always given with your answer.

Questions 7 and 8 are synoptic in nature. In response to these questions, you are encouraged to bring together principles and concepts of physics to show comprehension, and to use skills of physics in the analysis of data.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + ½at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = 1 / \sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0 \, e^{-t/CR}$
pressure of an ideal gas,	$p = Nm<c^2> / 3V$
radioactive decay,	$x = x_0 \, e^{-mt}$
	$l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^2 / 8\pi G$
relativity factor,	$\gamma = \sqrt{\{1 - v^2/c^2\}}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$

Answer **all** the questions in the spaces provided.

1 **(a)** The radius of the Hydrogen-1 nucleus is approximately 1.3×10^{-15} m. The mass of the proton is 1.67×10^{-27} kg.

(i) Estimate a value for the density of the nucleus of Hydrogen-1.

density = ...**[3]**

(ii) Suggest, with a reason, whether the density of the nucleus of Uranium-235 has approximately the same value as that in **(i)**.

………………………………..……………………………………………

………………………………………………………………………..……

……………………………………………………………………………… **[1]**

(b) The centres of mass of two protons in a nucleus are separated by a .distance of 2.6×10^{-15} cm. Calculate

(i) the gravitational force between the two protons,

gravitational force = ... N **[2]**

(ii) the electrostatic force between the two protons.

electrostatic force = ... N **[2]**

(c) Explain why your answers in **(b)** indicate that there must be another interaction between nucleons.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

[2]

(d) State one physical phenomenon which may be explained by

(i) the strong interaction,

……………………………………………………………………………………… **[1]**

(ii) the weak interaction.

……………………………………………………………………………………… **[2]**

2 **(a)** In a nuclear reactor, a uranium nucleus $^{238}_{92}U$ absorbs a neutron to form a new isotope of uranium.

(i) Write down a nuclear equation for this absorption process.

…………………………………………………………………………………………

[1]

(ii) The new isotope of uranium decays by β^- emission to an isotope of neptunium (Np). Write down a nuclear equation for this decay.

…………………………………………………………………………………………

[2]

(b) It is suggested that some radioactive waste could be stored underground in simple metal containers and would not cause damage to the environment. Comment on this suggestion.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… **[4]**

3 The Joint European Torus (JET) fusion experiment involves the confinement of a plasma.

(a) Explain what is meant by a plasma.

……...............................…………………...………

……..…………………..…………

………...…...…………... **[2]**

(b) State the method by which the plasma in the JET experiment is confined.

………..……………...............................

………...…………...

…………..............................……….. **[2]**

(c) State two possible advantages of using nuclear fusion reactors as an energy source.

1. ....…………..…….

....……………..…..

2. ....…………………..…...

....……………… **[2]**

(d) The electric potential energy E_p of two isolated hydrogen nuclei, a distance *r* apart, is given by the expression

$$E_p = q^2 / 4\pi e_0 r^2,$$

where *q* is the charge on a proton.

(i) Calculate the electric potential energy of the two hydrogen nuclei when their separation is 2.6×10^{-15} m.

energy = ... **[1]**

(ii) For fusion of two hydrogen nuclei to take place, the separation of the nuclei must be less than 2.6 x 10^{-15} m. Given that the kinetic energy E_k of a hydrogen nucleus is related to the thermodynamic temperature T by the expression E_k = 2.07 x 10^{-23} T, estimate a minimum value for the temperature of a sample of hydrogen for fusion of its nuclei to be possible.

temperature = ... K **[2]**

(iii) The temperature of the interior of the Sun is of the order of 10^7 K. Comment on this statement in relation to your answer in (ii).

....

....

....

.... **[2]**

4 Read the following passage, and answer the questions which follow.

In a synchrotron, a pulse of particles is made to follow a circular path many times within an evacuated tube. A special device, called a cavity, is arranged on the circle and provides an alternating electric field which accelerates the particles. The oscillations of the electric field are synchronised so that each time the pulse of particles crosses the cavity, it gains energy. The pulse of particles is held in a circular path during this process by powerful electromagnets placed around the path, as illustrated in Fig. 4.1. The strength of the magnetic field is continually increased during the process of acceleration.

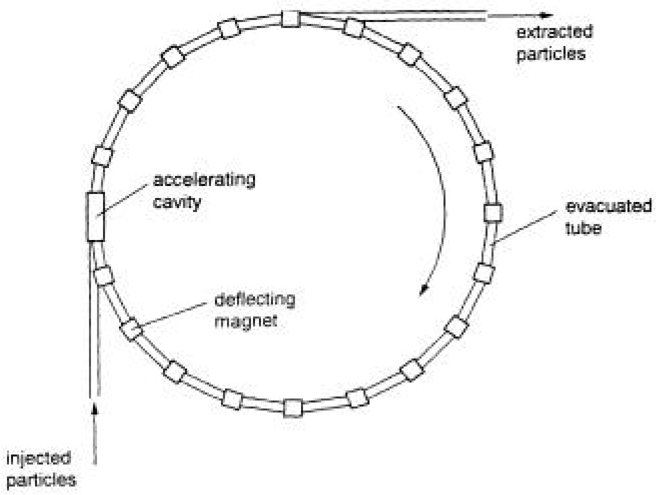


Fig. 4.1

(a) State why the synchrotron tube is evacuated.

.... **[1]**

(b) The particles in this accelerator are protons and the path is clockwise, as illustrated in Fig. 4.1. On Fig. 4.1, draw an arrow labelled E to show the direction of the electric field in the cavity as the protons pass through it. **[2]**

(c) Explain why it is necessary to increase the magnetic field strength during the acceleration of a pulse of particles.

....

....

.... **[2]**

(d) State two differences between the principles of operation of a synchrotron and those of a cyclotron.

1. ....

....

....

2. ....

....

.... **[4]**

5 **(a)** Explain the terms

(i) antiparticle,

....

....

.... **[2]**

(ii) annihilation.

....

....

.... **[2]**

(b) A positron and an electron annihilate in a collision when the particles are moving in opposite directions at the same low speed.
Calculate

(i) the total energy in eV evolved in the annihilation process,

energy = ... eV **[3]**

(ii) the frequency of one of the photons produced.

frequency = ...Hz **[2]**

6 **(a)** Fig. 6.1 shows the variation with proton number *Z* of the neutron number *N* for stable nuclei.

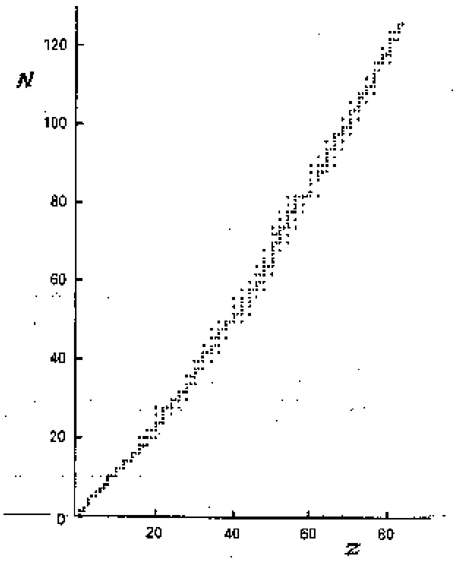


Fig. 6.1

The nuclide $^{123}_{56}$Ba emits a β-particle. Use Fig. 6.1 to predict whether this particle is a β^- or a β^+ particle. Explain your reasoning.

....

....

....

....

.... **[4]**

(b) State the effect of the emission of a β^- particle on the quark composition of the nucleus.

....

....

.... **[2]**

(c) (i) Distinguish between leptons and hadrons.

....

....

.... **[2]**

(ii) Describe a simple quark model of hadrons, making reference to two different particles.

....

....

....

....

.... **[3]**

7 The fission products from a nuclear reactor are analysed to determine the relative yields *Y* of various nuclides. The nuclides have nucleon numbers *A*.

The results are tabulated in Fig. 7.1, together with lg *Y*.

A	Y	lg Y
70	6.8×10^{-8}	-7.17
80	6.2×10^{-4}	-3.21
90	5.0×10^{-2}	-1.30
100	2.2×10^{-2}	-1.66
110	1.0×10^{-3}	-3.00
120	1.2×10^{-4}	-3.92
130	1.7×10^{-3}	-2.77
140	5.0×10^{-2}	-1.30
150	1.1×10^{-2}	-1.96
160	7.3×10^{-6}	-5.14

Fig. 7.1

(a) Comment on the number of significant figures shown in the table.

....

....

.... **[2]**

(b) On Fig. 7.2, plot a graph of lg *Y* (y-axis) against nucleon number *A* (x-axis). Your graph should be approximately symmetrical about a vertical line. **[4]**

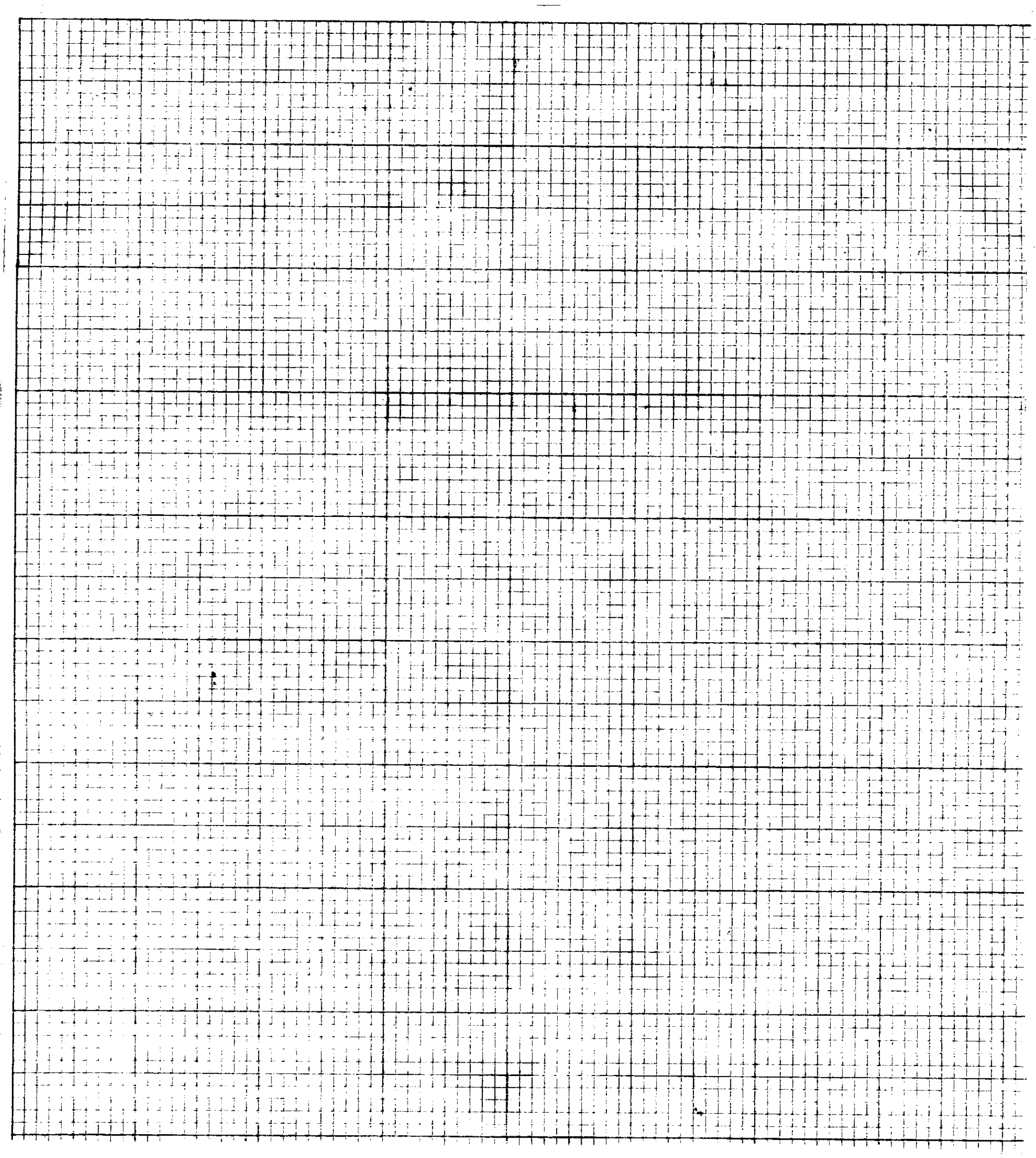


Fig. 7.2

(c) Suggest why lg *Y* has been used rather than *Y*.

....

.... **[1]**

(d) Use your graph in Fig. 7.2 to determine the value of *A* about which the graph is symmetrical.

A = ... **[1]**

(e) By reference to neutron induced fission, suggest why the graph should be symmetrical.

....

....

.... **[2]**

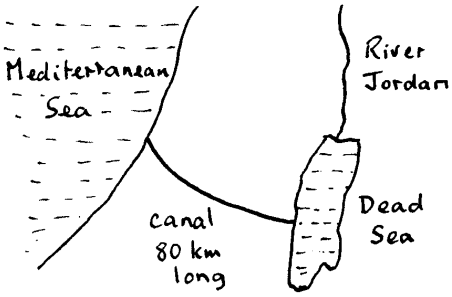
8 The following paragraph is based on a scientific article.

The World Bank is considering the construction of a vast hydroelectric project to bring fresh water to Israel, Jordan and Palestine. The project would involve building a canal from the Mediterranean Sea to the Dead Sea, which lies 400 m below sea level. The canal would have hydroelectric plants to generate electricity for desalination plants at intervals along its length.

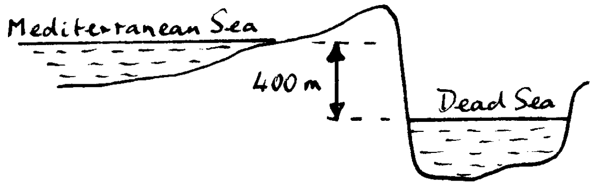
The desalination plants could produce up to 100 million cubic metres of fresh water per year. At present the Dead Sea is fed by the river Jordan, but there has been so much extraction of water for drinking and irrigation that in summer the flow of the river has been reduced to little more than a muddy trickle. The Dead Sea, the salinity of which makes it the densest body of water on Earth, is prone to rapid evaporation and, as more water has been tapped, the level has fallen by 3.0 metres in the last 35 years. The canal project would be a way of stopping this decline.

In carrying out detailed studies on the project, engineers have the following additional geographical and physical data.

Surface area of the Dead Sea	880 km^2
Energy required to vaporise 1 kg of water	2.3×10^6 J
Mean power absorbed by water from sunlight during daylight	300 W m^{-2}
Acceleration of free fall	9.8 m s^{-2}
Density of sea water in Mediterranean Sea	1030 kg m^{-3}



Sketch map of area



Cross-section

Answer the following questions about this project using the data supplied.

(a) What reason does the passage suggest for the Dead Sea being the 'densest body of water on Earth'?

....………………...............................

....…………….......................... **[1]**

(b) Calculate the power absorbed by the Dead Sea from the Sun during daylight.

power = ...W **[2]**

(c) If 60% of the power calculated in **(b)** is used to evaporate water from the Dead Sea, calculate the mass of water which evaporates in 12 hours of daylight.

mass = ... kg **[3]**

(d) Using the overall fall of the level of the Dead Sea, estimate the change during the last 35 years in the mass of water in the Dead Sea.

mass = ... kg **[3]**

(e) As the water falls from the Mediterranean Sea into the Dead Sea it loses one form of energy. What form of energy is this?

....……………… **[1]**

(f) Assume that the proposed project aims to refill the Dead Sea to its former level in the next 35 years. Estimate the power available from the water falling from the Mediterranean Sea into the Dead Sea.

power = ... W **[4]**

(g) A desalination plant operates on a cycle by evaporating water vapour from sea water and then condensing the water vapour back into fresh water. Explain why less than 2.3 x 106 joules are needed for each kilogram of fresh water produced in the cycle.

....

....

.... **[2]**

(h) State and explain two physical problems which will make the desalination scheme less efficient than indicated in **(f)**.

1. ....

....

....

....

....

2. ....

....

....

.... **[4]**

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

NUCLEAR AND PARTICLE PHYSICS **2825/04**

Mark Scheme

1	**(a)**	**(i)**	density = mass / volume and volume = $4/3\pi r^3$	C1	
			= $(1.67 \times 10^{-27} \times 3) / (4\pi \times \{1.3 \times 10^{-15}\}^3)$	C1	
			= 1.8×10^{17} kg m^{-3}	A1	
		(ii)	should be about same	M0	
			because it has same type of nuclear material	A1	**[4]**
	(b)	**(i)**	$F = Gmm / r^2$ or clear substitution	C1	
			$F = 2.8 \times 10^{-35}$ N	A1	
		(ii)	$F = Qq / 4\pi\varepsilon_0 r^2$ or clear substitution	C1	
			$F = 34$ N	A1	**[4]**
	(c)		repulsive force much greater than attractive force	M1	
			hence need for a strong attractive force	A1	**[2]**
	(d)	**(i)**	e.g. nuclear binding	B1	
		(ii)	e.g. beta decay	B1	**[2]**
2	**(a)**	**(i)**	${}^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{239}_{92}U$ *(-1 each error or omission)*	B2	
		(ii)	${}^{239}_{92}U \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e$ *(-1 each error or omission)*	B2	**[4]**
	(b)	e.g.	ground acts as good shield	B1	
			satisfactory for short time	B1	
			but half-lives likely to be long	B1	
			corrosion, leakage etc	B1	**[4]**
			(allow other relevant points)		
3	**(a)**		very hot matter	B1	
			electrons no longer attached to nucleus	B1	**[2]**
	(b)		magnetic containment	B1	
			field in shape of a toroid	B1	**[2]**
	(c)	e.g.	deuterium is abundant fuel		
			waste products not radioactive		
			on system failure, stops automatically		
			(1 each, max 2)	B2	**[2]**
	(d)	**(i)**	$E_p = (2.3 \times 10^{-28}) / (2.6 \times 10^{-15}) = 8.8 \times 10^{-14}$ J	B1	**[1]**
		(ii)	$8.8 \times 10^{-14} = 2 \times 1.5 \times 1.38 \times 10^{-23} \times T$	C1	
			$T = (8.8 \times 10^{-14}) / (2 \times 1.5 \times 1.38 \times 10^{-23})$		
			$= 2.1 \times 10^9$ K	A1	**[2]**
		(iii)	most unlikely that hydrogen will fuse	M1	
			must be some other reaction	A1	**[2]**

4	**(a)**		particles would collide with gas molecules	B1	**[1]**
	(b)		arrow tangential	B1	
			in cavity upwards	B1	**[2]**
	(c)		for circular motion, $Bqv = mv^2 / r$	M1	
			v increases (q, m and r constant), B must increase	A1	**[2]**
	(d)	e.g.	radius of orbit	M1	
			increases in cyclotron	A1	
			cyclotron has constant magnetic field	M1	
			whereas it varies in synchrotron	A1	
			(M1, A1 for each, max. 4)		**[4]**
5	**(a)**	**(i)**	particle having same mass & opposite charge	B1	
			e.g. electron / positron	B1	
		(ii)	matter and antimatter combine	M1	
			to give photons only	A1	**[4]**
	(b)	**(i)**	$E = \Delta m.c^2$	C1	
			$= 2 \times 9.1 \times 10^{-31} \times (3.0 \times 10^8)^2$		
			$= 1.64 \times 10^{-13}$ J	C1	
			$= 1.02 \times 10^6$ eV	A1	
		(ii)	$E = hf$	C1	
			$= ½ \times (1.64 \times 10^{-13}) / (6.63 \times 10^{-34})$		
			$= 1.24 \times 10^{20}$ Hz	A1	**[5]**
6	**(a)**		number of neutrons in Barium-123 = 67	B1	
			nuclide located below curve	M1	
			to return to stability, neutrons increase		
			or protons decrease	A1	
			this can be achieved by β^+ emission	A1	**[4]**
	(b)		down quark in neutron	B1	
			becomes an up quark	B1	**[2]**
	(c)	**(i)**	leptons, weak force; hadrons, strong force	B1	
			hadrons made up of quarks, leptons are		
			fundamental particles	B1	**[2]**
		(ii)	reference to u, d and s quarks	B1	
			reference to charge on quarks	B1	
			neutron as udd, proton as uud	B1	**[3]**
7	**(a)**		2 sig. fig for Y (and probably for A)	M1	
			3 sig. fig. for lg Y since first figure is only giving		
			the power of ten	A1	**[2]**
	(b)	graph:	sensible axes	B1	
			points plotted *(-1 each error or omission)*	B2	
			reasonable line	B1	**[4]**
	(c)		range of values too great a span for linear graph	B1	**[1]**

	(d)	118	B1	**[1]**
	(e)	idea of total number of nucleons constant	B1	
		two parts of about equal masses will always 'twin'	B1	**[2]**
8	**(a)**	prone to rapid evaporation	B1	**[1]**
	(b)	880 km^2 = 880 x 10^6 m^2	C1	
		power = 880 x 10^6 x 300		
		= 2.64 x 10^{11} W	A1	**[2]**
	(c)	$E = \Delta m.L$	C1	
		E = 0.60 x 2.64 x 10^{11} x 12 x 3600	C1	
		= 6.84 x 10^{15} J		
		m = (6.84 x 10^{15}) / (2.26 x 10^6)		
		= 3.03 x 10^9 kg	A1	**[3]**
	(d)	volume lost = 880 x 10^6 x 3	C1	
		= 2.64 x 10^9 m^3		
		mass = 2.64 x 10^9 x 1030	C1	
		= 2.7 x 10^{12} kg	A1	**[3]**
	(e)	(gravitational) potential energy	B1	**[1]**
	(f)	mass which can enter in nest 35 years		
		= 2 x 2.7 x 10^{12} kg	B1	
		power = mgh / t	C1	
		= (5.4 x 10^{12} x 9.8 x 400) / (35 x 365 x 86400)	C1	
		= 19.2 MW	A1	**[4]**
	(g)	heat required to produce evaporation	B1	
		can be recovered when steam condenses	B1	**[2]**
	(h)	e.g. 1. water will evaporate from systemso less potential energy available		
		2. water in canal has kinetic energy so less energy available for hydroelectric scheme		
		Statement, 1 each	B2	
		Explanation, 1 each	B2	**[4]**

NUCLEAR AND PARTICLE PHYSICS

ASSESSMENT GRID

Question Number	Learning Outcome	AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a) (i)	1 (c)	1	1				
(a) (ii)	4 (g) F		2			4	
(b)	1 (d)	2	2			4	
(c)	1 (d)	1	1			2	
(d) (i)	1 (e)	1					
(d) (ii)	5 (o)	1				2	12
2 (a) (i)	2 (c)	1	1				
(a) (ii)	4 (l) F	1	1			4	
(b)	2 (i)	3	1			4	8
3 (a)	3 (g)	1	1			2	
(b)	3 (m)	2				2	
(c)	3 (o)	2				2	
(d) (i)	3 (b)		1			1	
(d) (ii)	3 (d)		2			2	
(d) (iii)	3 (c)		2			2	11
4 (a)	4 (l)	l				l	
(b)	4 (l)	1	1			2	
(c)	4 (l)		2			2	
(d)	4 (f) (m)	2	2			4	9
5 (a) (i)	4 (a)	2					
(a) (ii)	4 (d)	2				4	
(b) (i)	4 (d)	1	2				
(b) (ii)	4 (d) B	1	1			5	9
6 (a)	5 (q)	1	3			4	
(b)	5 (r)	1	1			2	
(c) (i)	5 (g) (h) (j)	1	1			2	
(c) (ii)	5 (j) (k) (m) (n)	1	2			3	11
7 (a) – (e)	Synoptic				10	10	10
8	Synoptic				20	20	20
		30	30		30	90	90

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A
TELECOMMUNICATIONS **2825/05**

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Additional materials:

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elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + ½at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = 1 / \sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0 \mathrm{e}^{-t/CR}$
pressure of an ideal gas,	$p = Nm\langle c^2\rangle / 3V$
radioactive decay,	$x = x_0 \mathrm{e}^{-mt}$,
	$l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^2 / 8\pi G$
relativity factor,	$\gamma = \sqrt{} \{1 - v^2/c^2\}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$

Answer **all** the questions in the spaces provided.

1 **(a)** Fig. 1.1 illustrates a section of an amplitude modulated (AM) wave in which a single frequency sinusoidal signal is carried by a higher frequency carrier wave.

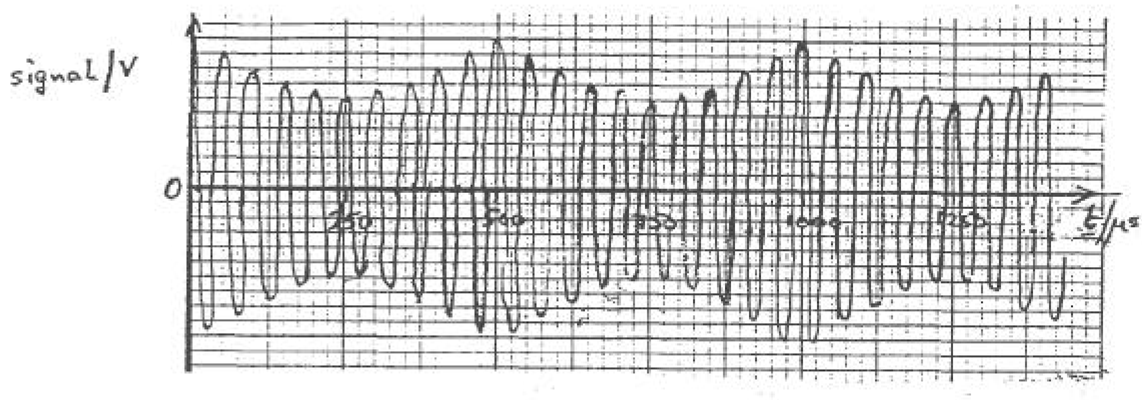


Fig. 1.1

(i) Show that the frequency of the carrier wave is 20 kHz. **[2]**

(ii) Determine the frequency of the signal.

frequency = ... Hz **[2]**

(iii) In the space below, sketch the frequency spectrum of the amplitude-modulated wave. **[3]**

(iv) Using your answer to **(ii)**, state the bandwidth of the signal.

bandwidth = ... **[1]**

(b) Explain, with the aid of a diagram, what is meant by *frequency modulation* (FM).

....

.... **[3]**

(c) State one advantage and one disadvantage of the transmission of an audio signal by FM as opposed to AM.

advantage ....

....

disadvantage...

.... **[2]**

2 Fig. 2.1 shows the variation with time t of the voltage V of an analogue signal.

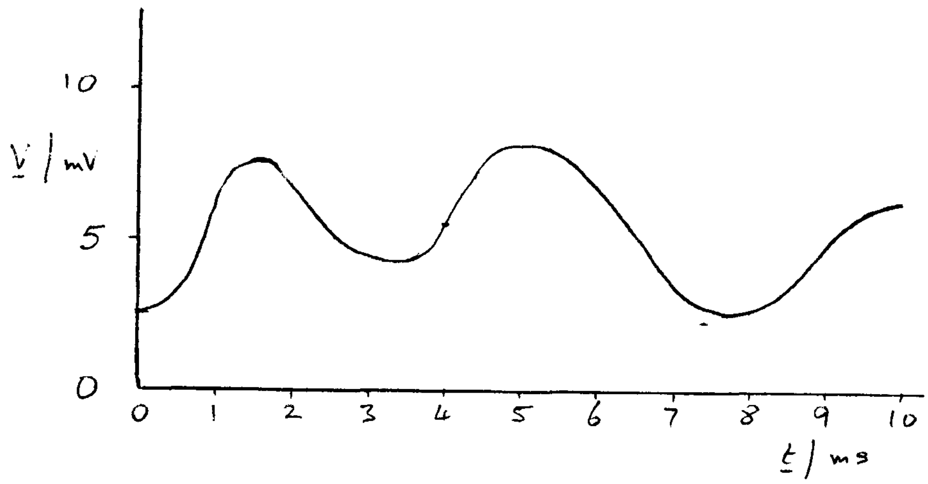


Fig. 2.1

The signal is to be converted into digital form with four-bit words using an analogue-to-digital converter.

(a) **(i)** The signal is sampled at t = 2.0 ms. State the magnitude of the sample.

magnitude = ... **[1]**

(ii) Another sample is taken at t = 4.0 ms and converted into binary form. Determine the binary form of the value of this sample. Label the most significant bit with an arrow. The least significant bit represents 0.50 mV.

binary form = ...

[3]

(b) **(i)** The signal is sampled every 2.0 ms and then transmitted to a receiver. It is then converted back into analogue form. Describe and explain the shape of the signal after transmission and conversion compared with the original signal of Fig. 2.1.

....

....

.... **[2]**

(ii) Suggest two changes to the analogue-to-digital converter by which the quality of the final signal may be improved.

1. ....

....

2. ....

....

[2]

(c) It is proposed to transmit several digital signals along the same channel at the same time.

Explain how this can be achieved using time-division multiplexing.

....

....

....

.... **[6]**

3 **(a)** Draw a labelled block diagram showing the basic elements of an amplitude-modulated radio receiver. **[5]**

(b) Explain the function of three of the elements shown in your diagram in **(a)**.

1. ....

....

2. ....

....

3. ....

.... **[3]**

4 **(a)** Describe one advantage and one disadvantage of a parabolic reflecting dish compared with a half-wave dipole, when each is used as a receiver antenna.

advantage..

....

disadvantage..

.... **[2]**

(b) Many communication systems rely on the use of satellites.

(i) Explain, with reference to a particular example, why geostationary satellites are often used in communication systems.

....

....

.... **[3]**

(ii) State and explain the range of frequencies usually used in satellite communications.

....

....

....

.... **[3]**

5 **(a)** **(i)** Complete Fig. 5.1 to show the circuit diagram of an inverting amplifier incorporating an operational amplifier (op-amp). **[3]**

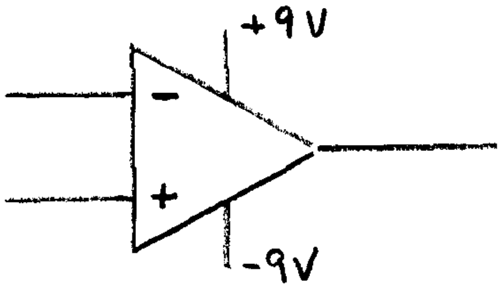


Fig. 5.1

(ii) On your diagram in Fig. 5.1, give component values so that the amplifier has a gain of -100. **[2]**

6 A group of students investigates the variation with distance *x* from a model transmitter of the power incident per unit area (the intensity) produced by the transmitter. The intensity is measured using a meter with scale readings *S*. The raw data obtained and the processed results are shown in Fig. 6.1.

meter reading S	distance x/ m^{-1}	$1/x$ /m^{-1}	$1/x^2$ / m-2	lg S	lg (x/m)
69	1.15	0.870	0.756	1.84	0.0607
61	1.22	0.820	0.672	1.79	0.0864
53	1.31	0.763	0.583	1.72	0.117
48	1.38	0.725	0.525	1.68	0.140
40	1.51	0.662	0.439	1.60	0.179
36	1.59	0.629	0.396	1.56	0.201

Fig. 6.1

(a) Suggest whether the processed data for lg S have been written down with an appropriate number of significant figures.

....

....

.... **[2]**

(b) One student states “the signal varies as the inverse square of the distance from the transmitter.”

(i) On Fig. 6.2, plot a suitable graph so that the truth of this statement may be tested. **[5]**

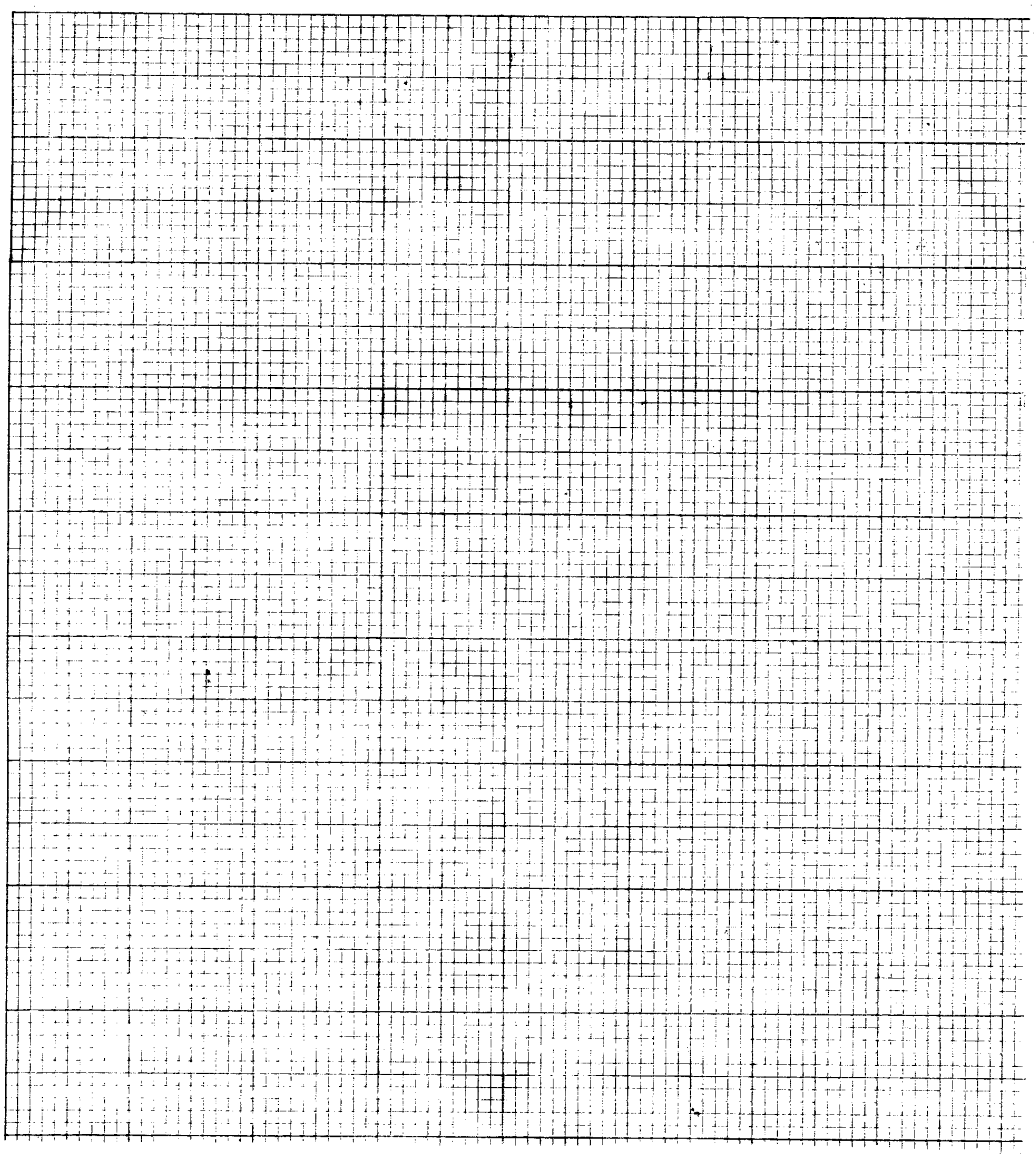


Fig. 6.2

(ii) Use your graph to provide evidence to comment on the student's statement.

comment ....

.... **[3]**

7 **(a)** Explain, with the aid of a diagram, the principles of operation of a cellular mobile telephone network.

....

....

....

....

.... **[6]**

(b) Describe the social, economic and technological changes which have taken place as a consequence of the introduction of modern communication systems.

....

....

....

....

....

....

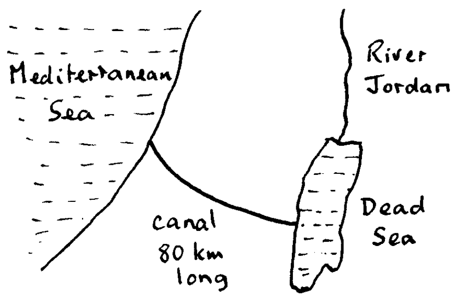
.... **[6]**

8 The following paragraph is based on a scientific article.

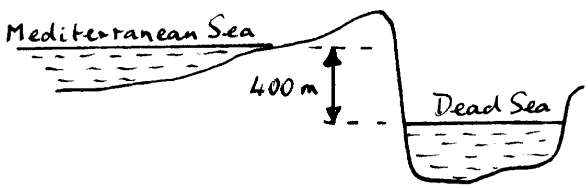
The World Bank is considering the construction of a vast hydroelectric project to bring fresh water to Israel, Jordan and Palestine. The project would involve building a canal from the Mediterranean Sea to the Dead Sea, which lies 400 m below sea level. The canal would have hydroelectric plants to generate electricity for desalination plants at intervals along its length. The desalination plants could produce up to 100 million cubic metres of fresh water per year. At present the Dead Sea is fed by the river Jordan, but there has been so much extraction of water for drinking and irrigation that in summer the flow of the river has been reduced to little more than a muddy trickle. The Dead Sea, the salinity of which makes it the densest body of water on Earth, is prone to rapid evaporation and, as more water has been tapped, the level has fallen by 3.0 metres in the last 35 years. The canal project would be a way of stopping this decline.

In carrying out detailed studies on the project, engineers have the following additional geographical and physical data.

Surface area of the Dead Sea	880 km^2
Energy required to vaporise 1 kg of water	2.3×10^6 J
Mean power absorbed by water from sunlight during daylight	300 W m^{-2}
Acceleration of free fall	9.8 m s^{-2}
Density of sea water in Mediterranean Sea	1030 kg m^{-3}



Sketch map of area



Cross-section

Answer the following questions about this project using the data supplied.

(a) What reason does the passage suggest for the Dead Sea being the 'densest body of water on Earth'?

....

.... **[1]**

(b) Calculate the power absorbed by the Dead Sea from the Sun during daylight.

power = ...W **[2]**

(c) If 60% of the power calculated in **(b)** is used to evaporate water from the Dead Sea, calculate the mass of water which evaporates in 12 hours of daylight.

mass = ... kg **[3]**

(d) Using the overall fall of the level of the Dead Sea, estimate the change during the last 35 years in the mass of water in the Dead Sea.

mass = ... kg **[3]**

(e) As the water falls from the Mediterranean Sea into the Dead Sea it loses one form of energy. What form of energy is this?

.... **[1]**

(f) Assume that the proposed project aims to refill the Dead Sea to its former level in the next 35 years. Estimate the power available from the water falling from the Mediterranean Sea into the Dead Sea.

power = ... W **[4]**

(g) A desalination plant operates on a cycle by evaporating water vapour from sea water and then condensing the water vapour back into fresh water. Explain why less than 2.3×10^6 joules are needed for each kilogram of fresh water produced in the cycle.

....

....

....

.... **[2]**

(h) State and explain two physical problems which will make the desalination scheme less efficient than indicated in **(f).**

1. ....

....

....

....

....

2. ....

....

....

....

.... **[4]**

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

TELECOMMUNICATIONS **2825/05**

Mark Scheme

1	**(a)**	**(i)**	frequency = n / t	M1	
			correct substitution	M1	
			answer 20 kHz	A0	**[2]**
		(ii)	T = 500 μs	C1	
			f = $1/T$ = 2.0 kHz	A1	**[2]**
		(iii)	single peak at 20 kHz	B1	
			two sidebands, lower amplitude	B1	
			labelled 18 kHz and 22 kHz	B1	**[3]**
		(iv)	4.0 kHz	B1	**[1]**
	(b)		Diagram showing change in frequency	B1	
			signal changes frequency of carrier	B1	
			any further detail	B1	**[3]**
	(c)		advantage e.g. better quality	B1	
			disadvantage e.g. more complex	B1	**[2]**
2	**(a)**	**(i)**	6.5 - 7.0 mV	B1	
		(ii)	sample = 5.5 mV	B1	
			1011	B1	
			msb labelled correctly	B1	**[4]**
	(b)	**(i)**	suitable sketch showing "steps"	B1	
			information lost etc.	B1	
		(ii)	e.g. increase number of bits	B1	
			increase sampling rate	B1	**[4]**
	(c)		diagram and/or words		
			several sources and equal number of destinations	B1	
			all sources sampled	B1	
			sample on channel at different times	B1	
			fixed sequence for samples	B1	
			alignment words	B1	
			further detail or quality of diagram	B1	**[6]**
3	**(a)**		Six elements identified *(-1 each omission)*	B3	
			and in correct "order" *(-1 each error)*	B2	**[5]**
	(b)		detail of any three (not expanded name) *(l each, max 3)*	B3	**[3]**
4	**(a)**		advantage e.g. detects weaker signals	B1	
			disadvantage e.g. more complex, expensive	B1	**[2]**
	(b)	**(i)**	want continuous steady signal	B1	
			so "source" should not be moving	B1	
			example given	B1	**[3]**
		(ii)	1's → 10's GHz	B1	
			e.g. Earth's atmosphere has conducting layers	B1	
			transparent at these frequencies	B1	**[3]**

5	**(a)**	input resistor and (+) input connection	B1	
		correct feedback shown	B1	
		input and output labelled	B1	**[3]**
	(b)	correct ratio	M1	
		sensible values	A1	**[2]**
6	**(a)**	raw data for *x* all to 3 sig. fig.	M1	
		so processed data to 3 sig. fig. - all OK	A1	**[2]**
	(b)	**(i)** lg - lg graph with suitable axes and labels	B2	
		(-1 if S v. $1/x^2$)		
		suitable scales	B1	
		correct plots *(-1 each error or omission)*	B2	**[5]**
		(ii) suitable triangle indicated for gradient	B1	
		finds gradient correctly	M1	
		conclusion	A1	**[3]**
7	**(a)**	country divided into cells	B1	
		radius depends on density of users	B1	
		each cell has own transmitter and receiver	B1	
		interface to PSTN	B1	
		transfer between receivers/transmitters }		
		when moving between cells }	B1	
		limit on number of channels/users per cell		
		any other detail to maximum of 6	B1	**[6]**
	(b)	one social e.g. speed of communication	B1	
		one economic e.g. greater cost of infrastructure		
		remote working possible	B1	
		one technical e.g. people "talk to machines"	B1	
		any three further points, 1 each	B3	**[6]**
8	**(a)**	prone to rapid evaporation	B1	**[1]**
	(b)	880 km^2 = 880 x 10^6 m^2	C1	
		power = 880 x 10^6 x 300		
		= 2.64 x 10^{11} W	A1	**[2]**
	(c)	$E = \Delta m.L$	C1	
		E = 0.60 x 2.64 x 10^{11} x 12 x 3600	C1	
		= 6.84 x 10^{15} J		
		m = (6.84 x 10^{15}) / (2.26 x 10^6)		
		= 3.03 x 10^9 kg	A1	**[3]**
	(d)	volume lost = 880 x 10^6 x 3	C1	
		= 2.64 x 10^9		
		mass = 2.64 x 10^9 x 1030	C1	
		= 2.7 x 10^{12} kg	A1	**[3]**
	(e)	(gravitational) potential energy	B1	**[1]**

(f)	mass which can enter in next 35 years		
	= 2 x 2.7 x 10^{12} kg	B1	
	power = *mgh / t*	C1	
	= (5.4 x 10^{12} x 9.8 x 400) / (35 x 365 x 86400)	C1	
	= 19.2 MW	A1	**[4]**
(g)	heat required to produce evaporation	B1	
	can be recovered when steam condenses	B1	**[2]**
(h)	e.g. 1. water will evaporate from system so less potential energy available 2. water in canal has kinetic energy so less energy available for hydroelectric scheme		
	Statement, 1 each	B2	
	Explanation, 1 each	B2	**[4]**

TELECOMMUNICATIONS

ASSESSMENT GRID

Question Number	Learning Outcome	Assessment Objective AO1	AO2	AO3	AO4	Section sub-total	Question total
1 (a) (i)	1 (c)(d), 2 (b)	1	1			2	
(a) (ii)	1 (c)(d), 2 (b)	1	1			2	
(a) (iii)	3 (c)	1	2			3	
(a) (iv)	2 (d)		1			1	
(b)	2 (b)	2	1			3	
(c)	2 (e)	2				2	13
2 (a)	2 (g)	2	2			4	
(b)	3 (e) (f)	2	2			4	
(c)	3 (g)	2	4			6	14
3 (a)	5 (b)	2	3			5	
(b)	5 (a)		3			3	8
4 (a)	5 (c)	2				2	
(b) (i)	5 (f)	1	2			3	
(b) (ii)	5 (g)	1	2			3	8
5 (a)	4 (e)	2	1			3	
(b)	4 (h) (i)	1	1			2	5
6	Synoptic				10	10	10
7 (a)	7 (i)	4	2			6	
(b)	7 (k)	4	2			6	12
8	Synoptic				20	20	20
		30	30		30	90	90

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

UNIFYING CONCEPTS IN PHYSICS **2826/01**

Specimen Paper

Candidates answer on the question paper.

Additional materials:

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Answer **all** the questions.

Write your answers in the spaces provided on the question paper.

For numerical answers, **all** working should be shown.

INFORMATION FOR CANDIDATES

The questions in this paper are synoptic in nature. In response to these questions, you are encouraged to show your knowledge and understanding of different areas of physics. You should bring together principles and concepts of physics, expressing your ideas clearly and logically, using appropriate scientific vocabulary.

The number of marks is given in brackets [] at the end of each question or part question.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$m_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$e_0 = 8.85 \times 10^{-12}$ F m^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + ½at^2$
	$v^2 = u^2 + 2as$
refractive index,	$n = 1 / \sin C$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + ...$
capacitors in parallel,	$C = C_1 + C_2 + ...$
capacitor discharge,	$x = x_0 \, e^{-t/CR}$
pressure of an ideal gas,	$p = Nm\langle c^2\rangle / 3V$
radioactive decay,	$x = x_0 \, e^{-mt}$,
	$l t_{½} = 0.693$
critical density of matter in the Universe,	$r_0 = 3H_0^2 / 8\pi G$
relativity factor,	$\gamma = \sqrt{\{1 - v^2 / c^2\}}$
current,	$I = nAve$

Answer **all** the questions in the spaces provided.

1 **(a)** A solar cell is a device for converting light energy directly into electrical energy.

Fig. 1.1 shows the current / voltage characteristic of a solar cell when connected to a variable resistor. The light power incident on the cell is constant.

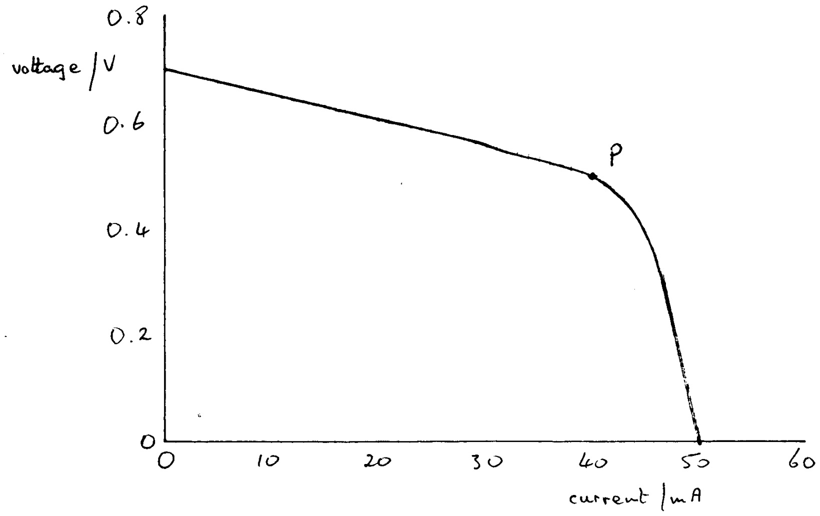


Fig. 1.1

(i) In the space below, draw a diagram of the circuit used in order to determine the characteristic shown in Fig. 1.1. [2]

(ii) Describe the variation with current of the power output of the cell as the current is increased from zero to its maximum value.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

…………………………………………………………………………………………….. [3]

(iii) Calculate the power output of the cell at the point marked P on Fig. 1.1.

power = ……………………. W [2]

(iv) Use data from Fig. 1.1 to determine

1. the e.m.f. of the cell,

e.m.f. = ………………………….. V [1]

2. the internal resistance of the cell when operating at point P.

internal resistance = …………………………… Ω [2]

(v) The light power incident on the cell is increased. Suggest three changes which will be seen in the shape of the current / voltage characteristic shown in Fig. 1.1. [3]

1.………………………………………………………………………………………

2.……………………………………………………………………………………..

3.……………………………………………………………………………………..

(b) An alternative means of generating electrical energy is to use the energy released during radioactive decay.

The nuclei of a radioactive isotope each emit one α-particle of energy 8.5×10^{-13} J as they decay. The half-life of the isotope is 72 years and its molar mass is 2.4×10^{-3} kg.

The energy of the α-particles is converted into electrical energy with an efficiency of 30%. It is required to produce a source of electrical energy with an output of 25 mW.

(i) Calculate

1. the activity of the source,

activity = ……………………….. Bq [3]

2. the disintegration constant of the radioactive isotope,

disintegration constant = ………………………… s^{-1} [3]

3. the mass of isotope required.

mass = ……………………………..…… kg
[3]

(c) Solar cells and radioactive sources have both been used as power sources for space probes. Discuss the relative advantages of the use of these two power sources. [4]

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

2 **(a)** A charged particle is situated in a field of force. The magnitude of the force on the particle is found to be independent of the speed of the particle and is in the opposite direction to that of the field.
Deduce, with an explanation, the nature of this field of force. Also include reasons as to why two other fields of force could not have been responsible for this force. [6]

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

(b) Give a quantitative argument as to why, for the development of a nuclear model of the atom, it is necessary to assume that there is a short-range strong force between protons.[6]

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

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3 An experiment is carried out to investigate the effectiveness of materials as absorbers of γ-ray photons. One possible experiment is illustrated in Fig. 3.1.

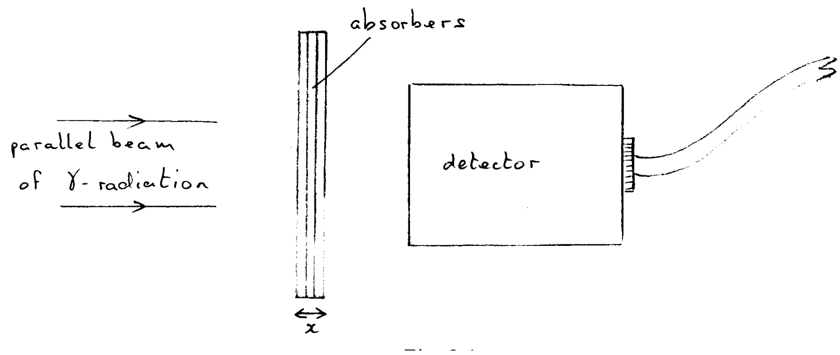

Fig. 3.1

The count-rate C_x of γ-ray photons is measured for various thicknesses x of absorber together with the count-rate C_0 for no absorber. Fig. 3.2 shows the variation with thickness x of the ratio C_x / C_0 for steel.

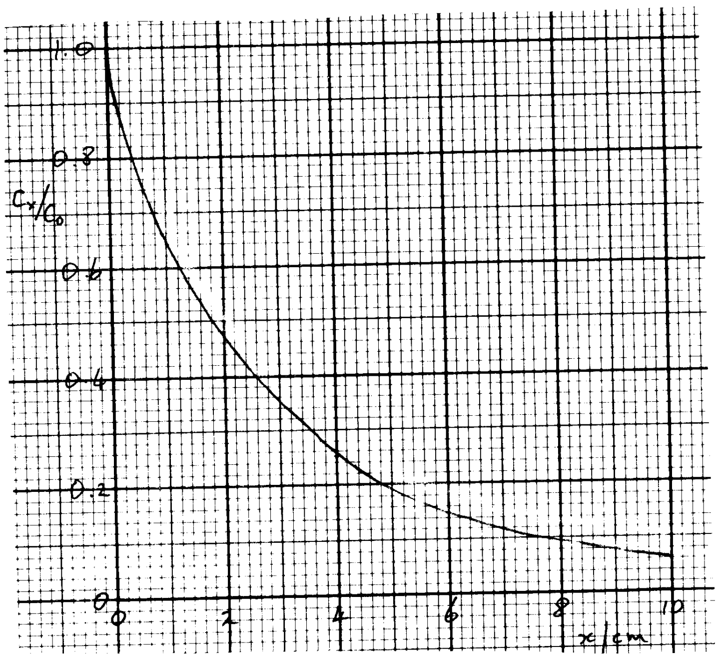

Fig. 3.2

(a) **(i)** Explain why it is necessary to have a parallel beam of γ-radiation.

………………………………………………………………………………………………

………………………………………………………………………………………………

(ii) Suggest why it is better to plot the variation with thickness x of C_x / C_0 rather than the variation with C_x.

………………………………………………………………………………………………

………………………………………………………………………………………………

(iii) State, with a reason, the evidence provided for the fact that, theoretically, complete shielding is not possible.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………[5]

(b) A γ-ray source of activity 2.0×10^{13} Bq, producing γ-radiation similar to that in **(a)** is sealed inside a steel container having walls of thickness 6.0 mm. The γ-ray photon energy is 3.1 MeV.

Determine the rate of deposition of energy, in watts, in the walls of the container.

rate = ……………………………. W [4]

(c) The experiment in **(a)** is repeated for absorbers of different materials. It is found that, for the same level of shielding, the required thickness of concrete is five times greater than that of lead.

Make three suggestions as to why concrete is used, in preference to lead, for the construction of shielding where radioactive sources of high activity are to be used, such as in nuclear reactors.

[3]

1.…...……………………………………………………………………………………………

………………………………………………………………………………………………….

2.…………………………………………………………………………………………………

…………………………………………………………………………………………………….

3.…………………………………………………………………………………………………

…………………………………………………………………………………………………….

4 When a car has a brake test, the maximum braking force produced by operating the foot brake is measured together with the mass of the car.

In order to determine whether the brakes are satisfactory, the data are applied to a chart similar to that shown in Fig. 4.1. This chart has three vertical lines, marked with axes.

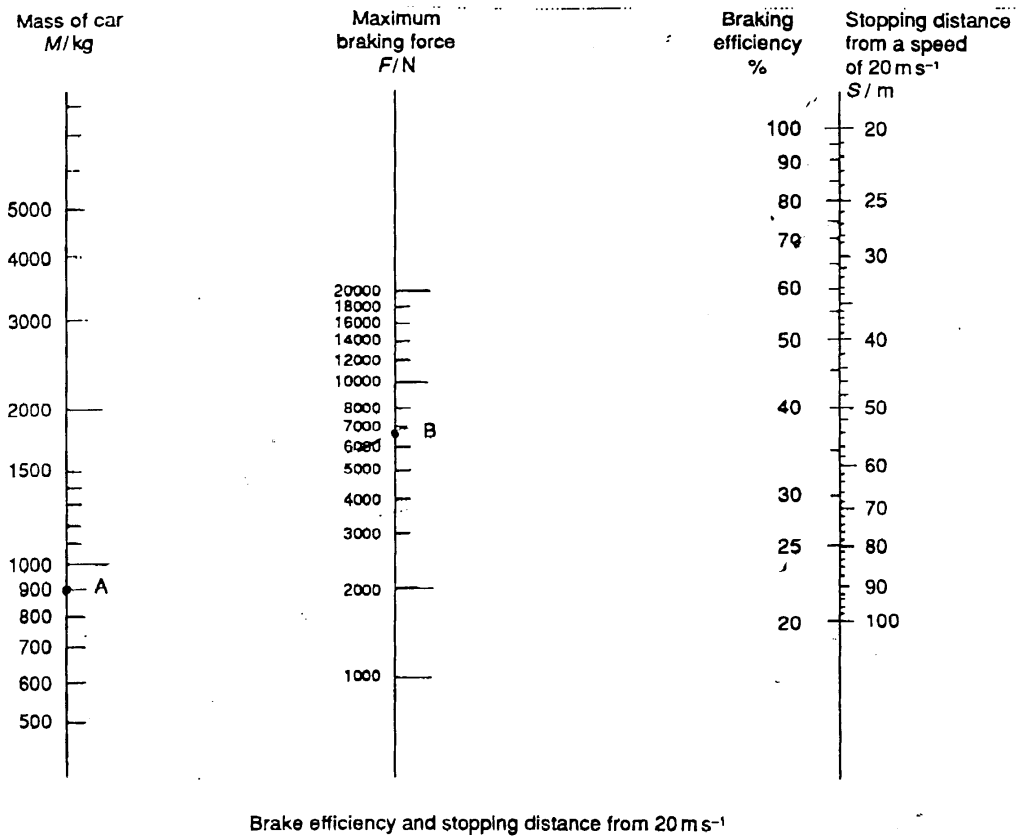

Fig. 4.1

The left line is for the mass of the car and the central line is for the maximum braking force.

The right-hand line is for the braking efficiency and also for stopping distance from an initial speed of 20 m s^{-1}. The braking efficiency is defined by the equation

$$E = \frac{\text{deceleration of car}}{\text{acceleration of free fall}} \times 100\%$$

As an example of the use of the chart, a car of mass 900 kg is found to have a maximum braking force of 6700 N. The point A corresponding to the mass and the point B corresponding to the braking force are joined to give a straight, sloping line. The line is extended to cut the right-hand line so that the braking efficiency and the stopping distance may be read off.

(a) Determine

(i) the braking efficiency for a car of mass 900 kg having a maximum braking force of 6700 N.

efficiency = ……………………………….. %

(ii) the deceleration corresponding to this braking efficiency.

deceleration = ……………………………….m s^{-2}

[3]

(b) Show, by calculation, that the deceleration in **(a)(ii)** gives a stopping distance corresponding to the braking efficiency determined in **(a)(i)**. [3]

(c) On a particular road surface, the stopping distance from 20 m s^{-1} is 50 m.

(i) Use Fig. 4.1 to determine the deceleration of the car,

deceleration = ……………………………….m s^{-2}

(ii) Determine the effective braking force.

force = ………………………………. N

[2]

(d) The braking efficiency in **(a)** is for a dry road surface.
Suggest, with a reason, what happens to braking efficiency when the surface is wet.

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….

……………………………………………………………………………………………………….
[2]

Oxford Cambridge and RSA Examinations

Advanced GCE

Physics A

UNIFYING CONCEPTS IN PHYSICS **2826/01**

Mark Scheme

1	**(a) (i)**	Diagram; Cell in series with ammeter and variable resistor	M1	
		voltmeter in parallel with cell	A1	[2]
	(ii)	At high V and low I, power is ‘low’	B1	
		At low V and high I, power is ‘low’	B1	
		Power peaks at some intermediate values of V and I	B1	[3]
	(iii)	power = VI	C1	
		$= 0.5 \times 40 \times 10^{-3} = 20$ mW	A1	[2]
	(iv)	1. e.m.f = 0.7V	B1	[1]
		2. E – V = Ir		
		$0.7 - 0.5 = 40 \times 10^{-3}$ r	C1	
		r = 5.0 O	A1	[2]
	(v)	e.g. emf increases		
		maximum current increases		
		maximum power output increases (1 each)	B3	[3]
	(b) (i)	1. Power required = 10/3 x 25 mW C1		
		activity $= (10/3 \times 25 \times 10^{-3}) / (8.5 \times 10^{-13})$	C1	
		$= 9.8 \times 10^{10}$ Bq	A1	[3]
		2. ? = ln 2/$t_{1/2}$ C1		
		= ln2 / 72 x 365 x 24 x 3600	C1	
		$= 3.1 \times 10^{-10}$ s^{-1}	A1	[3]
		3. A = ?N		
		$N = 9.8 \times 10^{10} / 3.1 \times 10^{-10}$	C1	
		$= 3.2 \times 10^{20}$		
		mass $= (3.2 \times 10^{20} / N_A) \times 2.4 \times 10^{-3}$	C1	
		= 1.26 μg	A1	[3]
	(c)	e.g. solar cell; no pollution in space		
		output decreases as move away from Sun		
		radioactive source; independent of distance from Sun		
		potential pollutant		
		power decreases with time		
		etc 1 each	B4	[4]
2	**(a)**	Field is electric	M1	
		because $F_E = E_q$ so independent of speed	A1	
		and with neg. charge F_E & E are opposite in direction	A1	
		Cannot be magnetic	M0	
		Because F = Bqv so depends on speed	A1	
		and F_B perpendicular to B	A1	
		Cannot be gravitational	M0	
		Because F_G & field always in same direction	A1	[6]
	(b)	In nucleus, electric & gravitational forces on protons	B1	
		$F_E/F_G = Q^2/4p?_0Gm^2$	B1	
		$= 1.2 \times 10^{36}$	B1	
		force of repulsion >> force of attraction	B1	
		so strong force required to overcome repulsion	B1	
		short range because applies only within nucleus	B1	[6]

3	**(a) (i)**	so all photons "see" same thickness of absorber	B1	
	(ii)	y-axis is independent of initial count-rate OR scale limited to 0 ? 1	B1	
	(iii)	for complete shielding $C_x/C_o = 0$	B1	
		line approaches zero but never touches it	B1	
		any further detail in (i), (ii) or (iii)	B1	[5]
	(b)	at x = 6.0 mm, $C_x/C_o = 0.74$	C1	
		number of photons absorbed $s^{-1} = (1 - 0.74) \times 2 \times 10^{13}$	C1	
		energy $s^{-1} = 5.2 \times 10^{12} \times 1.6 \times 10^{-13} \times 3.1$	C1	
		= 2.6W	A1	[4]
	(c)	e.g. cost ease of construction/shaping/moulding/strength 1 each	B3	[3]
4	**(a) (i)**	75%	B1	
	(ii)	0.75 = a/9.8	C1	
		a = 7.35 ms^{-2}	A1	[3]
	(b)	$v^2 = u^2 + 2as$	C1	
		$0 = 20^2 - 2 \times 7.35 \times s$	M1	
		s = 400/ 14.7 = 27.2 m QED as read from graph	A1	[3]
	(c) (i).	Efficiency = 40% retardation = 0.4 x 9.8 = 3.9 ms^{-2}	B1	
	(ii)	use of chart (3600 N) OR calculation (3500N)	B1	[2]
	(d)	the stopping distance is increased	M1	
		and so braking efficiency decreases	A1	[2]