INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS | INDEX NUMBER

PHYSICS 9646/02

Paper 2 Structured Questions **16 September 2013**

1 hour 45 minutes

Candidates answer on the Question Paper

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

For Section A
Answer **all** questions.
It is recommended that you spend about 1 hour and 15 minutes on this section.

For Section B
Answer Question 8.
It is recommended that you spend about 30 minutes on this section.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 6
2	/ 10
3	/ 8
4	/ 8
5	/ 6
6	/ 7
7	/ 15
8	/ 12
Significant Figures	
Total	/ 72

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	$= 8.85 \times 10^{-12}$ 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}
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}$ J K^{-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	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
mean kinetic energy of a molecule of an ideal gas	E	$= \frac{3}{2}kT$
hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	Φ	$= -\frac{GM}{r}$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t$
		$= \pm\omega\sqrt{\left(x_o^{\,2} - x^2\right)}$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= Q/4\pi\varepsilon_o r$
alternating current/voltage,	x	$= x_o \sin\omega t$
transmission coefficient	T	$= \exp(-2kd)$
		where $k = \sqrt{\dfrac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	$= x_o \exp(-\lambda t)$
decay constant,	λ	$= \dfrac{0.693}{t_{1/2}}$

Section A

Answer **all** the questions in this section.

1 A stone is being thrown from the top of the cliff with velocity 13 m s^{-1} at 50^{o} to the horizontal as shown in Fig. 1.1.

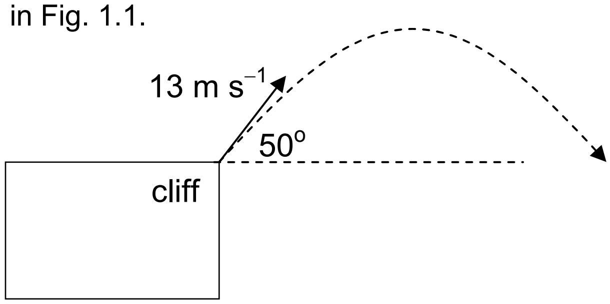

Fig. 1.1

(a) On the axes of Fig. 1.2, ignoring air resistance, draw and label graphs to represent the variation with time of

(i) V_H, the horizontal component of the velocity,

(ii) V_V, the vertical component of the velocity of the stone. Take upwards as positive direction. [3]

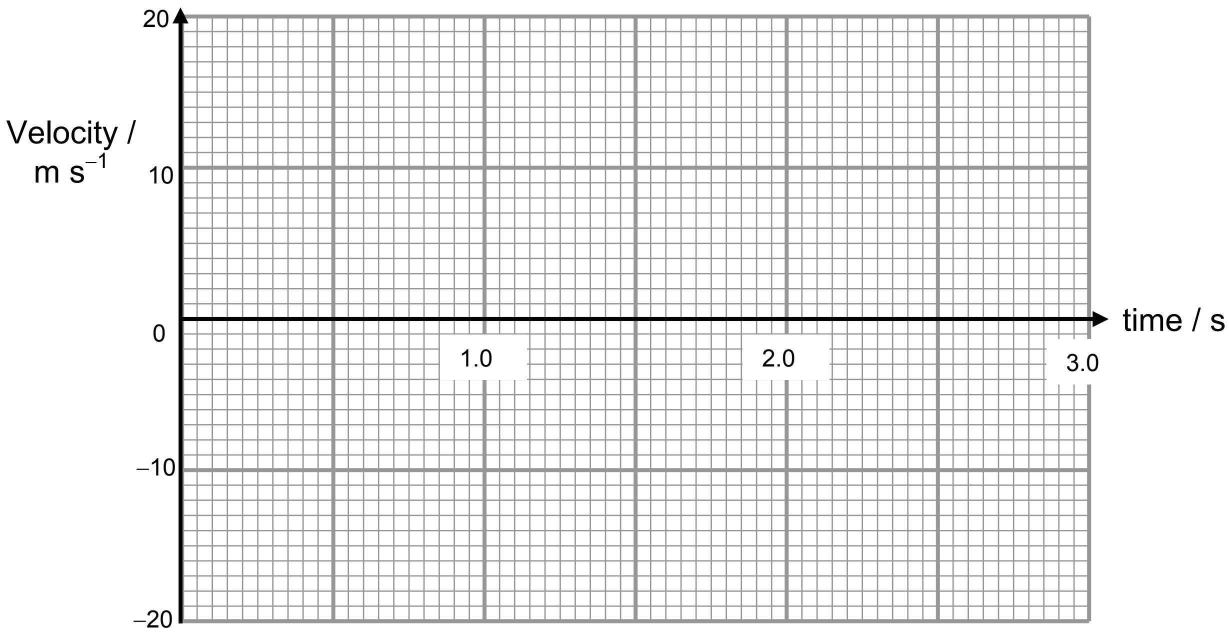

Fig. 1.2

(b) Using your answer in **(a)**, calculate the maximum vertical height *h* of the stone above its point of projection.

h = ………………………………. m [1]

(c) State and explain how the value in **(b)** will be affected if air resistance is considered.

For Examiner's Use

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....[2]

For Examiner's Use

2 **(a)** A moon is in a circular orbit of radius r about a planet. The planet and its moon may be considered to be point masses that are isolated in space. Show that, for the moon in circular orbit, the period T of the orbit is given by the expression

$$T^2 = \alpha r^3$$

where α is a constant. Explain your working.

[3]

(b) Phobos and Deimos are moons that are in circular orbits about the planet Mars. Data for Phobos and Deimos are shown in Fig. 2.1.

Moon	Radius of orbit / 10^6 m	Period of rotation about Mars / hours
Phobos	9.39	7.65
Deimos	19.9	T

Fig. 2.1

(i) Using the expression in **(a)** and the data from Fig. 2.1, determine the period of Deimos, T, in its orbit about Mars.

T = …………………………… hours [2]

(ii) The period of rotation of Mars about its axis is 24.6 hours. Deimos is in an equatorial orbit, orbiting in the same direction as the spin of Mars about its axis. Use your answer in **(i)** to comment on the orbit of Deimos.

……………………………………………………………………………………………

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

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(c) A binary star consists of two stars that orbit about a fixed point C, as shown in Fig. 2.2.

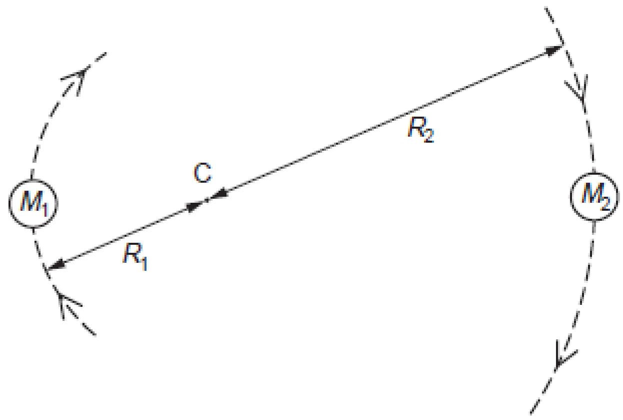

Fig. 2.2

The star of mass M_1 has a circular orbit of radius R_1 and the star of mass M_2 has a circular orbit of radius R_2. Both stars have the same angular speed ω, about C.

(i) State the formula, in terms of G, M_1, M_2, R_1, R_2 and ω for

1. the gravitational force between the two stars, [1]

2. the centripetal force on the star of mass M_1. [1]

(ii) Suggest why M_1 is of a bigger mass compared to M_2.

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....[2]

For Examiner's Use

3 (a) State the *first law of thermodynamics*.

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....[2]

(b) Fig. 3.1 shows two isothermal p−V graphs for a fixed mass of an ideal gas trapped in a cylinder by a piston.

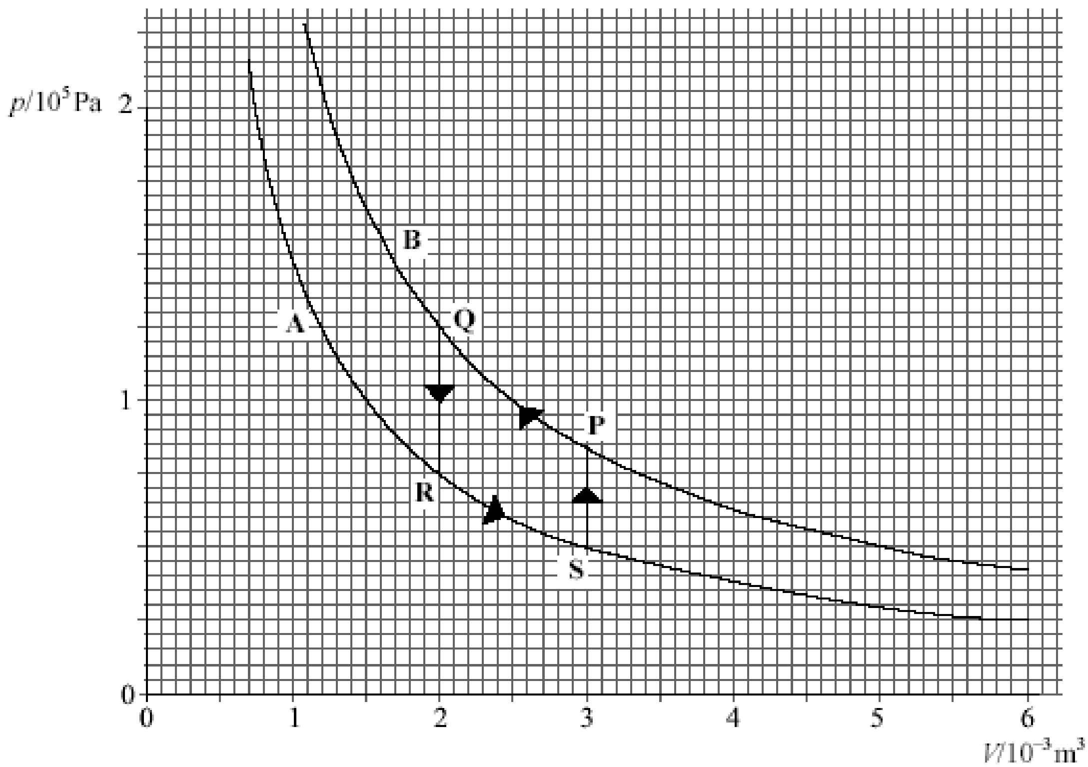

Fig. 3.1

(i) Isotherm **A** is for a temperature of 340 K. Calculate the temperature for isotherm **B**. Show your reasoning clearly.

temperature = ……………………………. K [2]

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(ii) The gas is taken around the cycle of changes **PQRSP** shown by the arrows on Fig. 3.1. Use the graph to estimate the net work done during the cycle.

work done = …………………………… J [2]

(iii) Hence determine the net heat supplied to the gas during the cycle.

net heat supplied = …………………………… J [2]

4 A mass M is moving at a speed of 5.00 m s^{-1} along a horizontal frictionless guide which bends into a vertical circle of radius r, as illustrated in Fig. 4.1.

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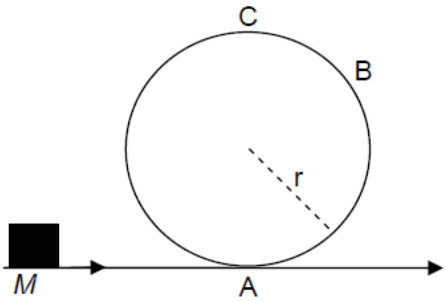

Fig. 4.1

Fig. 4.2 shows the the variation of the horizontal velocity of the mass with time along the section ABC of the curve.

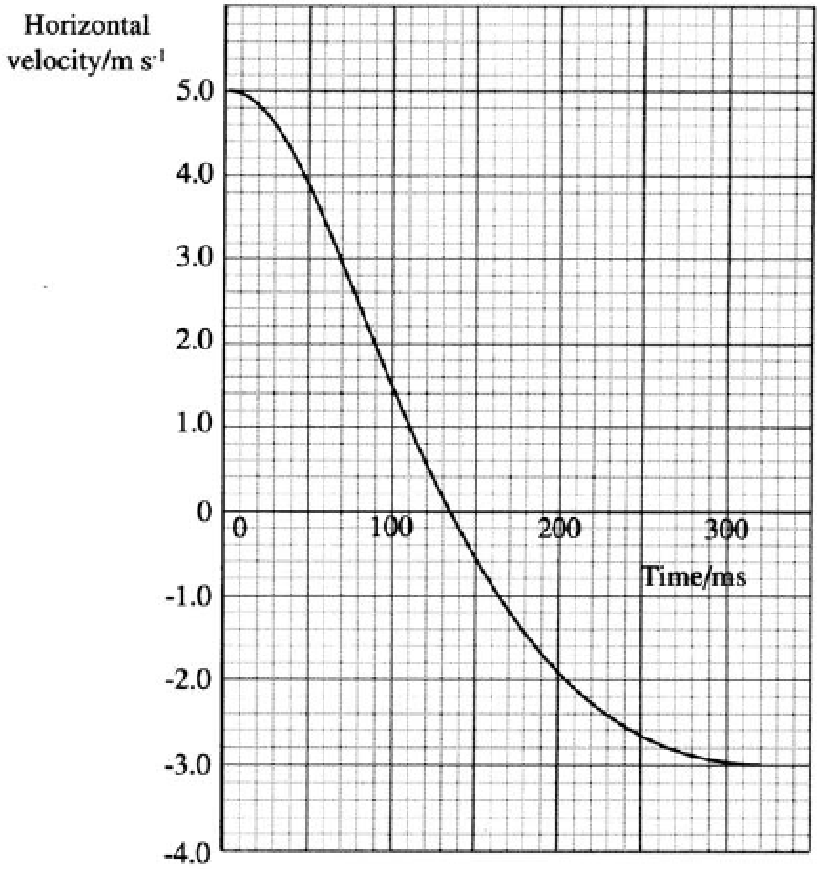

Fig. 4.2

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(a) **(i)** Using the principle of conservation of energy and with the aid of Fig. 4.2, find an appropriate value for the height of the vertical circle.

height of vertical circle = ……………………………. m [2]

(ii) Hence, find the value for the radius *r* of the vertical circle.

radius of vertical circle = ……………………………. m [1]

(iii) Show that the minimum speed v_c for the mass *M* to remain in contact with the track when it is at point C is $v_c = \sqrt{g r}$, where *g* is the acceleration of free fall. [2]

(b) Another mass 8M is moving with the same kinetic energy along the same horizontal frictionless guide which bends into the same vertical circle of radius r, as illustrated in Fig. 4.3.

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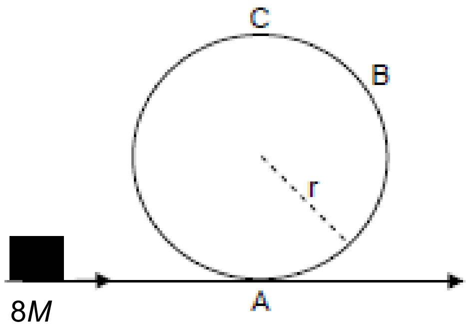

Fig. 4.3

With reference to your answer in **(a)(iii)** and the principle of conservation of energy, explain whether the mass 8M is able to pass through point C and travel back to point A.

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....[3]

For Examiner's Use

5 The graph in Fig.5.1 shows the variation of the e.m.f. induced in a coil when a bar magnet fell through it.

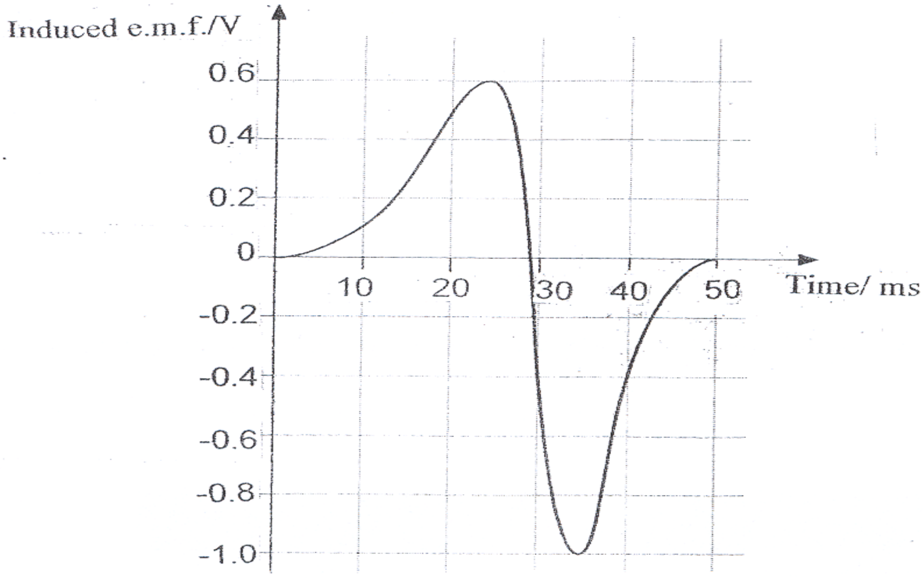

Fig. 5.1

(a) Explain, using the laws of electromagnetic induction, why

(i) two momentary deflections in opposite directions are observed, and

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....[2]

(ii) the second momentary deflection is larger than the first.

....

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....

....[2]

(b) With reference to Fig. 5.1,

For Examiner's Use

(i) state the quantity which the area under the graph represents.

....[1]

(ii) state the maximum rate of change of flux linkage.

maximum rate = ………………………….. Wb s^{-1} [1]

6 (a) The first four energy levels of a fictitious element X are shown in Fig. 6.1.

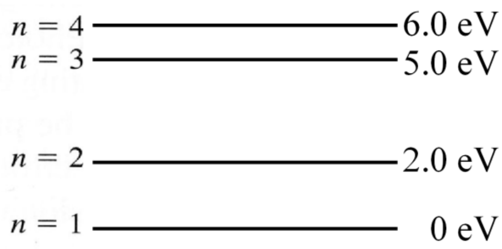

Fig. 6.1

Calculate the shortest wavelength observed in the absorption spectrum of cool atoms of element X.

shortest wavelength = …………………………… m [2]

(b) Spectra A and B in Fig. 6.2 below are both due to the fictitious element X.

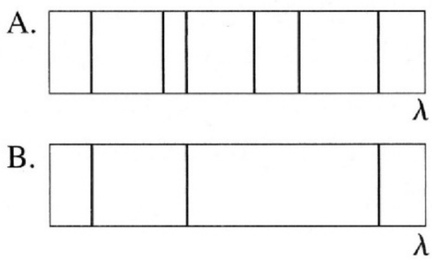

Fig. 6.2

(i) Identify which spectrum is an emission spectrum and which is an absorption spectrum.

....

....[1]

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(ii) Explain why the two spectra are different.

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....[2]

(iii) Explain how spectrum A shows that the energy levels in X are quantized.

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....[2]

For Examiner's Use

7 An object that is at a higher temperature than its surroundings loses thermal energy by emitting electromagnetic radiation.
For loss of thermal energy as electromagnetic radiation, the intensity I_λ of the emitted radiation of wavelength λ varies with wavelength λ as shown in Fig. 7.1.

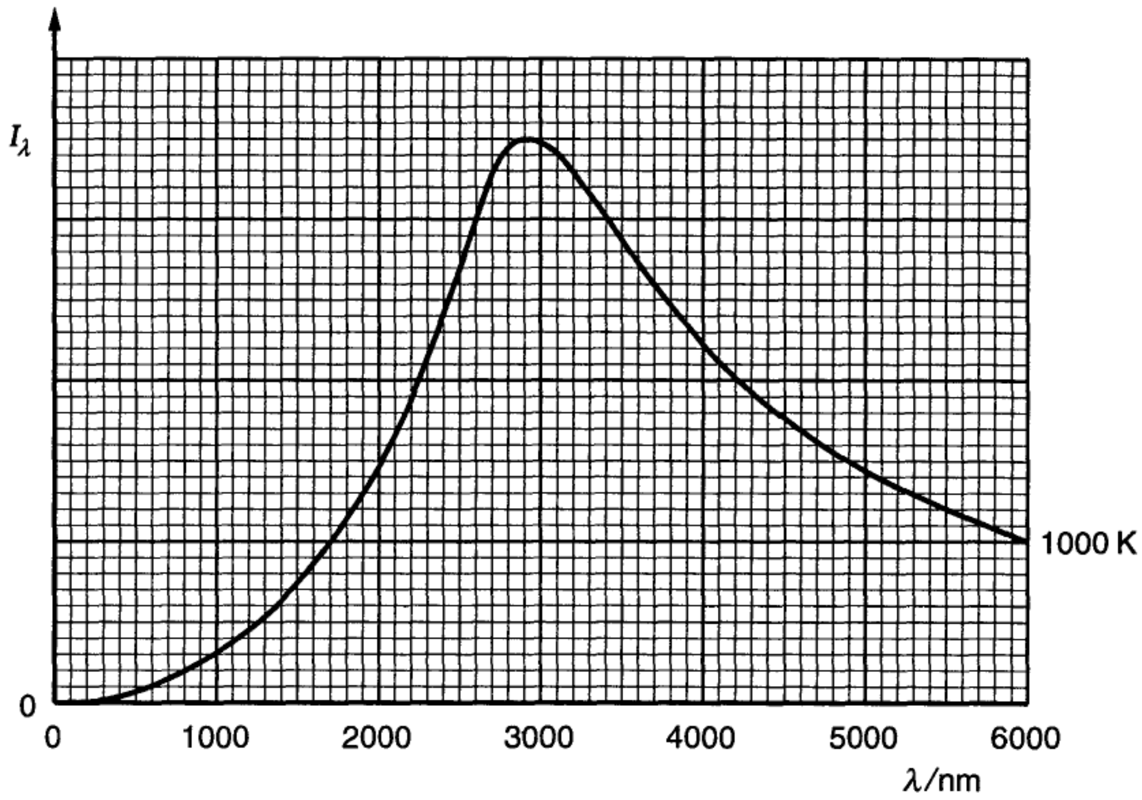

Fig. 7.1

Fig. 7.1 shows the variation of I_λ with λ for the body when it is at 1000 K. The distribution of intensity is different at different temperatures. This is illustrated in Fig. 7.2.

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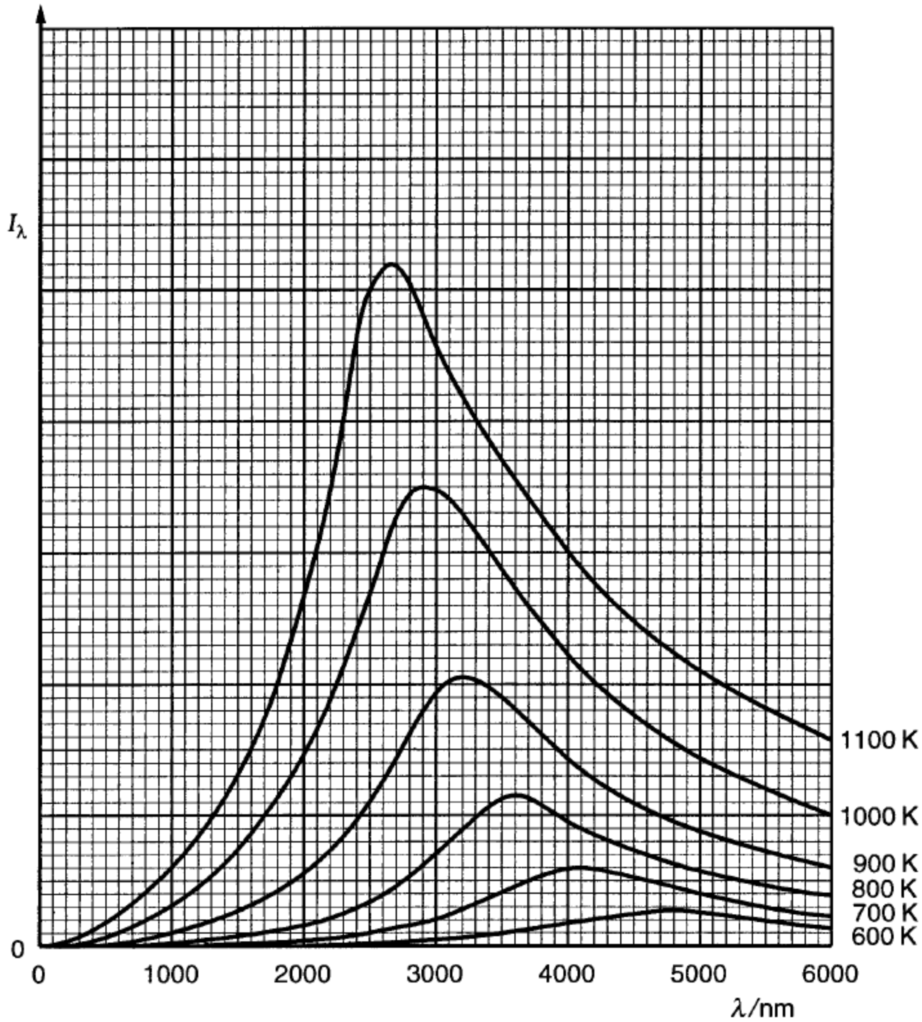

Fig. 7.2

(a) **(i)** On the horizontal axis of Fig. 7.2, indicate with the letter V a wavelength that is in the visible region of the electromagnetic spectrum. [1]

(ii) Hence suggest why, at a temperature of 1100 K, the object would glow with a red colour.

....

....[1]

(b) At any temperature T, the graph of Fig. 7.2 shows a peak corresponding to a wavelength λ_{max} and an intensity I_{max}. Data for T and λ_{max} are shown in Fig. 7.3.

T / K	λ_{max} / nm
600	4830
700	4140
800	3610
900	3210
1000	2900
1100	2630

Fig 7.3

For Examiner's Use

(i) Without drawing a graph, show that

$$T \times \lambda_{max} = \text{constant},$$

and determine the constant.

constant = ... nm K [3]

(ii) Hence, determine the wavelength for maximum intensity at a temperature T of 1200 K.

wavelength = ... m [2]

(c) The total intensity of emitted radiation from a particular body at temperature T is I_{tot}. Fig. 7.4 shows the values of lg(T/K), plotted against the corresponding values of lg(I_{tot} /W m^{-2}).

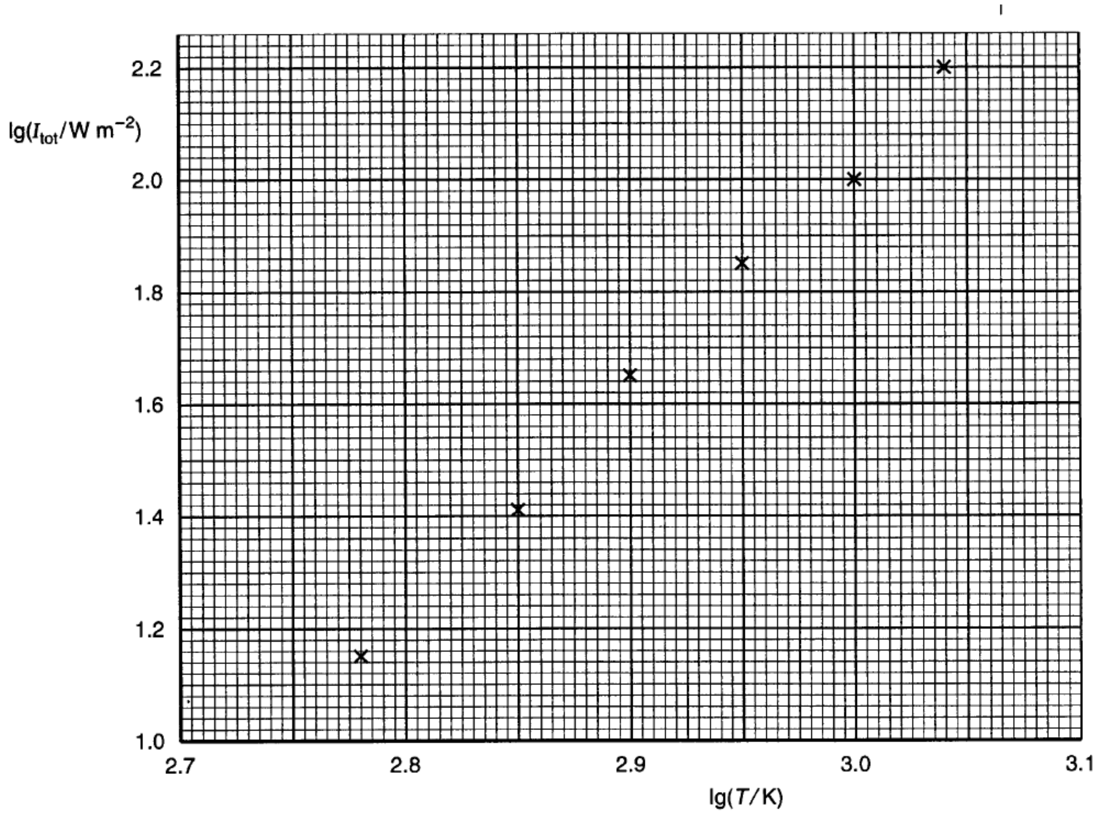

Fig 7.4

It is known that I_{tot} varies with T according to the relation

$$I_{tot} = cT^n,$$

where c and n are constants.

(i) Use Fig. 7.4 to determine a value for n.

n = ... [3]

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(ii) For this body at T = 627°C, I_{tot} is found to be 71 W m^{-2}.

Use these data and your answer to **(i)** to determine I_{tot} for the body at a temperature of 1200 K.

I_{tot} = ... W m^{-2} [3]

(d) The radiation emitted by a hot body may be used as a means of determining the temperature of the body. This can be done by first determining the wavelength at maximum intensity for the radiation emitted.

Suggest one advantage and one disadvantage of this method for measuring temperature.

Advantage: ....

....

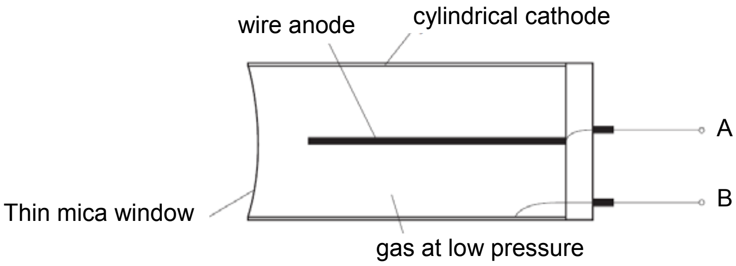
Disdvantage: ....

....[2]

Section B

It is recommended that you spend about 30 minutes on this section.

8 One type of radiation detector known as the Geiger-Muller tube is shown.



In order for the tube to function, a potential difference V_{AB} has to be applied between A and B. The Geiger-Muller tube can detect α, β and γ-radiation. The count rate of the radiation can be measured by a suitable counter placed across A and B.

Design a laboratory experiment to investigate how the count rate due to γ-radiation **only** depends upon the potential difference V_{AB}. You have access to three different radioactive sources only. Information relating to each of these sources is given in the table below.

Source	Type of radiation emitted	Half-life of source
Radium – 226	α, β and γ	1600 years
Bismuth – 214	β and γ only	20 minutes
Cobalt – 60	β and γ only	5 years

You may assume that the following equipment is available, together with any other apparatus that may be found in a school or college science laboratory.

Aluminium plates of different thicknesses	Variable d.c. power supply
Lead plates of different thicknesses	Oscilloscope
Geiger-Müller tube	Voltmeter
Ratemeter	Ammeter
Scalar	Signal generator
Source handling tool	Metre rule
Datalogger	Connecting wires

You should draw a diagram showing the arrangement of your apparatus. In your account you should pay particular attention to

(a) which source you would use, giving a reason for your choice,

(b) the procedure to be followed, including how the count rate would be measured,

(c) the control of variables,

(d) any safety precautions you would take. [12]

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Diagram

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END OF PAPER