NATIONAL JUNIOR COLLEGE

PRELIMINARY EXAMINATIONS

HIGHER 1

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS

8866/02

Paper 2 Structured Questions

31 Aug 2016

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THE INSTRUCTION FIRST

Write your subject class, registration number and name 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.

The use of an approved scientific calculator is expected where appropriate.

Section A

Answer **all** questions.

Section B
Answer any **two** questions. Please circle on the front page the questions you are submitting.

You are advised to spend about one hour on each section.

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

For Examiner's Use	
Section A (40 Marks)	
1	
2	
3	
4	
5	
Section B (40 Marks)	
6	
7	
8	
Total (80m)	

This document consists of 20 printed pages, including this cover page.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-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
acceleration of free fall,	g	$= 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	s	$= ut + ½at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
hydrostatic pressure,	p	$= \rho gh$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$

Section A

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

1 (a) (i) By reference to equations of motion, derive an expression for the kinetic energy, E_k, of an object of mass m moving at speed v.

[2]

(ii) It is often stated that many forms of transport transforms chemical energy into kinetic energy. Explain briefly why a cyclist travelling at constant speed is not making such transformation.

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(b) A car, of mass 720 kg, travelling along a horizontal road with a constant speed of 31 m s^{-1} would require a power of 36.6 kW.

(i) Determine the work done in overcoming the external forces opposing the motion of the car during a time of 5.0 minutes.

Work done = ……………………. J [2]

(ii) Hence, with reference to **(b)(i)**, suggest, with a reason, whether it would be worthwhile to develop a system whereby when the car slows down, its kinetic energy would be stored for re-use when the car speeds up again.

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2 (a) Show how the conservation of linear momentum can be derived using Newton's laws.

[3]

(b) When two strong magnets are held stationary with the north pole of one pushed against the north pole of the other. On letting go, the magnets spring apart. It is apparent that the kinetic energy of the magnets has increased.

(i) Explain how the law of conservation of momentum applies in this case.

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(ii) Suggest why the kinetic energy of the magnets increased.

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3 (a) Lightning strikes can involve current as high as 25 000 A that lasts for about 40 μs. If a person is struck by a bolt of lightning with these properties, the current will pass through his body. The resistance of a human body varies from approximately 500 kΩ (when it is very dry) to about 1.0 kΩ (when it is wet). The maximum safe current is about 5.0 mA.

(i) Define electric current and resistance.

Electric Current: …………………………………………………………………....

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…………………………………………………………………………………….[1]

Resistance: ……………………………………………………………………..…....

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

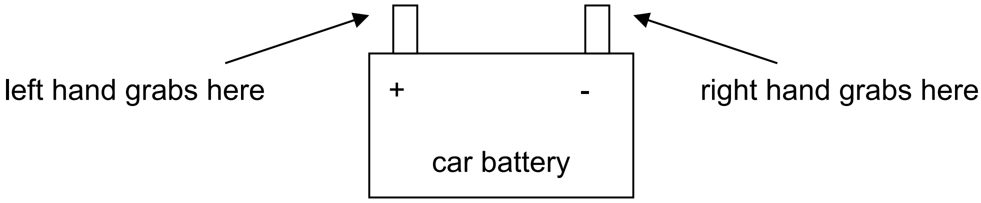
(ii) How much charges will flow through the person when the lightning described above strikes him?

Amount of Charge = ………………..C [1]

(iii) What is the largest safe potential difference across a wet human body?

Largest potential difference = …………………….V [2]

3 **(b)** A car mechanic with an average body resistivity of 5.0 Ω m, is trying to repair a car when his hands accidentally grasp the terminals of a 14 kV car battery with internal resistance of 2000 kΩ.



(i) The conducting path between the hands can be represented as a cylinder of 1.6 m long and 0.10 m in diameter. What is the resistance between his left hand and his right hand?

Resistance = ……………………….Ω [2]

(ii) An electrician claimed that the potential difference between his hands is not equal to 14 kV. Do you agree? Explain clearly.

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

(iii) With suitable calculations, determine if the current will kill the car mechanic (i.e. current exceeding the maximum safe current).

Current = …………………….A [2]

4 **(a)** State the Principle of Superposition.

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(b) In an experiment to determine the speed of sound, a long tube, fitted with a tap, is filled with water. A tuning fork is sounded above the top of the tube as the water is allowed to run out of the tube, as shown in Fig. 4.1 and Fig. 4.2.

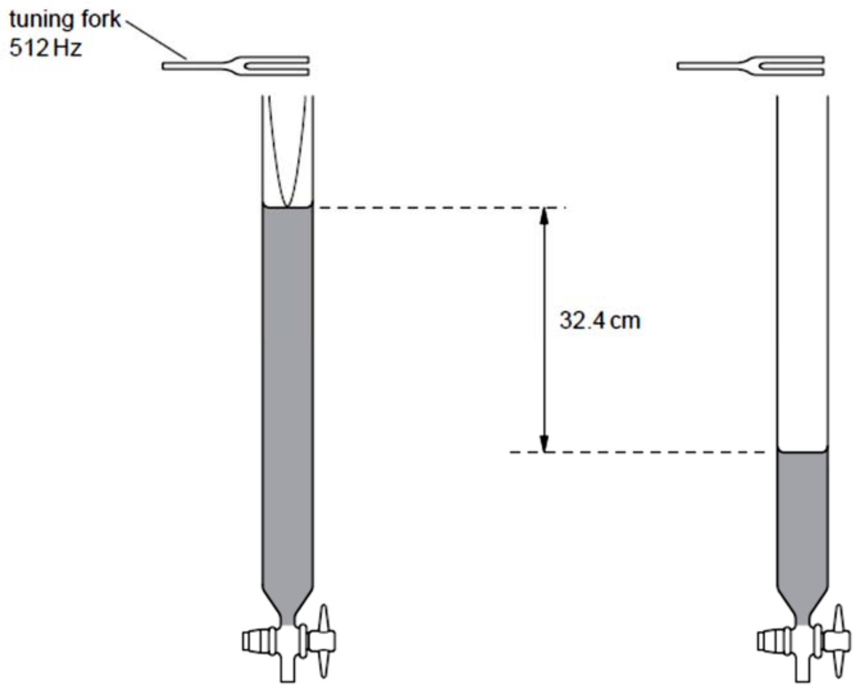

Fig. 4.1 **Fig. 4.2**

A loud sound is first heard when the water level is as shown in Fig. 4.1, and then again when the water level is as shown in Fig. 4.2. Fig. 4.1 illustrates a stationary wave produced in the tube.

(i) Explain the formation of a stationary wave in the tube.

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4 (b) (ii) Explain why the loudness of the sound changes as the water level changes.

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(iii) The frequency of the fork is 512 Hz and the difference in the height of the water level for the two positions where a loud sound is heard is 32.4 cm.
Calculate the speed of the sound in the tube.

speed of sound = ……………………. m s^{-1} [3]

(iv) The length of the column of air in the tube in Fig. 4.1 is 15.7 cm. Suggest and explain where the antinode of the stationary wave produced in the tube in Fig. 4.1 is likely to be found.

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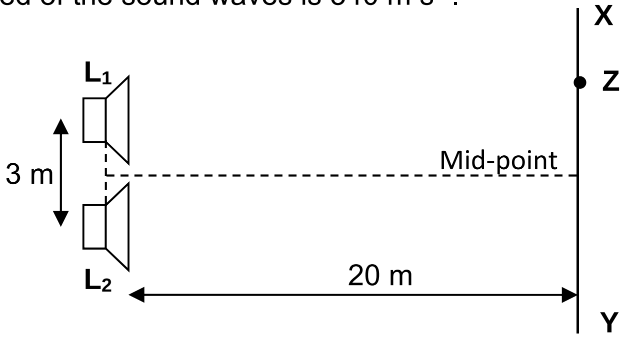
5 The loudspeakers L_1 and L_2 placed 3 m apart emit sound waves of frequency is 680 Hz, in phase. The speed of the sound waves is 340 m s^{-1}.



(a) State a condition, other than coherence, for observable interference patterns to be observed in region **XY**.

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

(b) Point **Z** represents a point at which is the 3rd instance where minimum intensity sound is heard as a microphone is moved from the mid-point towards **X**.

(i) Calculate the distance of **Z** from the mid-point.

Distance = …………………………….m [2]

(ii) When the loudspeaker L_2 is temporarily disconnected, a student finds that the intensity of the sound heard at **Z** increases. He finds this difficult to understand, as disconnecting L_2 presumably means that the total output energy from the loudspeakers decreases. Explain the result. Why it does not conflict with the law of conservation of energy?

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(c) The loudspeaker L_2 is now reconnected, but with the connections to its terminals interchanged, so that it emits sound waves in antiphase with those form loudspeaker L_1. What effect, if any, this will have on the signal received by a microphone placed along **XY** compared with the arrangement in **(b).**

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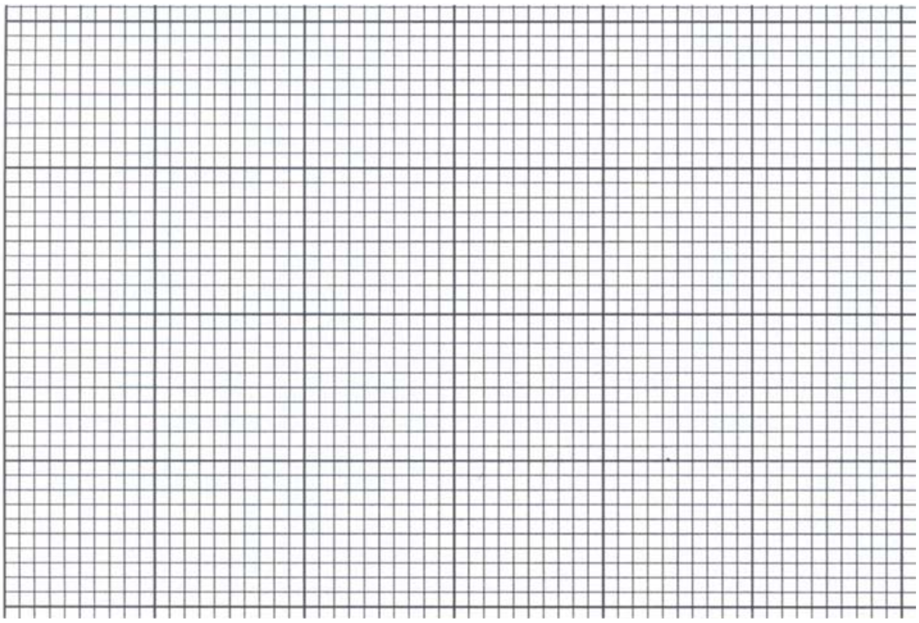
…………………………………………………………………………………………………… [1]

Section B (40 marks)
Choose **two** out of the three questions.

6 (a) (i) Two similar sports car A and B are used to do some road tests. They have different engines and thus provide different driving force. On a flat road, Car A can accelerate uniformly from rest to 100 km h^{-1} in 3.5 s while Car B can accelerate from rest to 100 km h^{-1} in 4.0 s.

1. Using the figure below, draw the velocity-time graphs for the two cars, accelerating from rest together at the start line, for the first 4.0 s. Label **A** and **B** for the graph representing car A and car B respectively. [2]



2. Using the graphs draw in **(i)1.**, calculate the distance, *d*, between car A and B at *t* = 4.0 s.

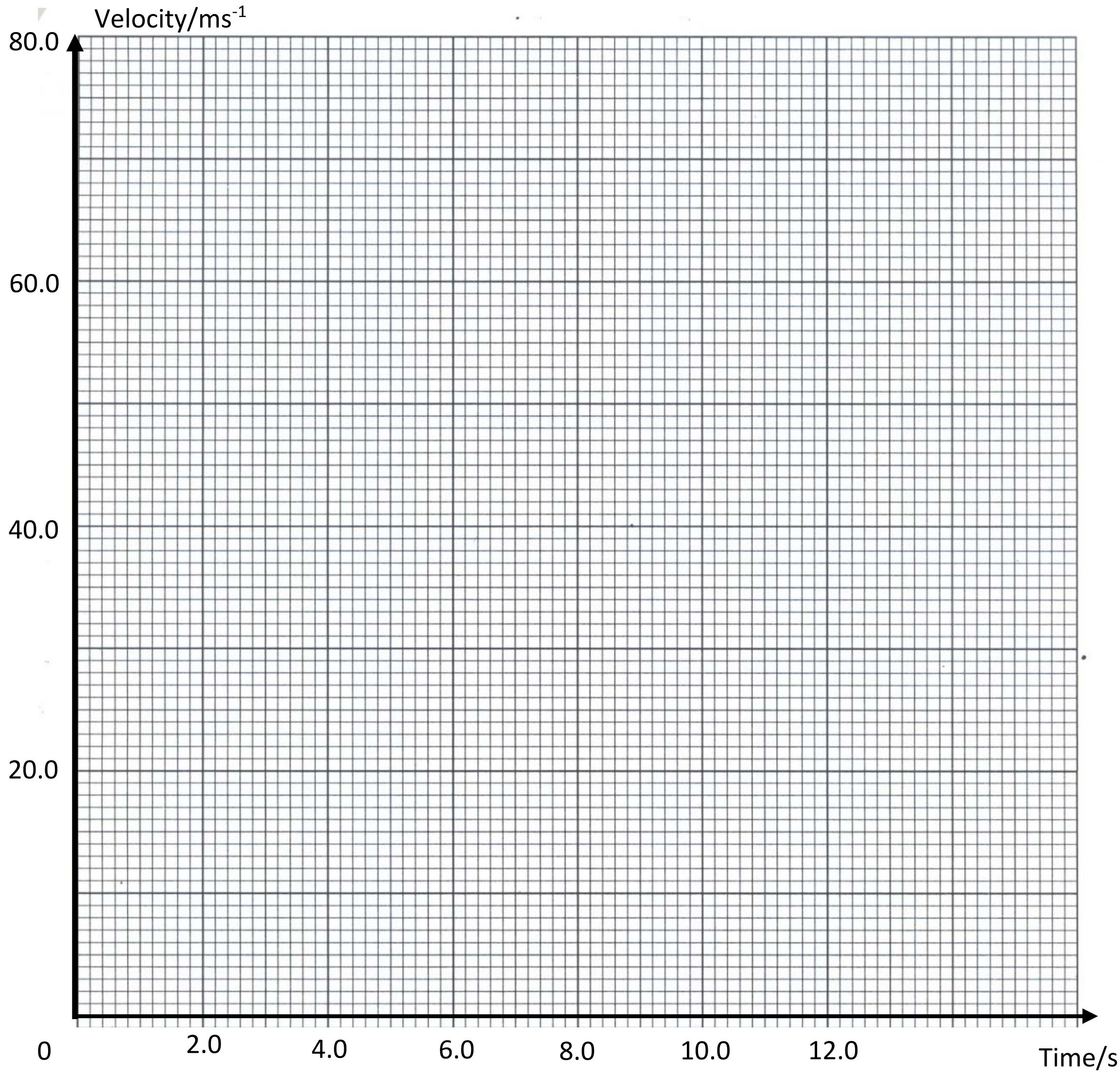
d =……………..m [2]

(ii) 1. When both cars encounter a slope, driving force of Car B remains the same while that of Car A is reduced by 20%. Calculate the effective acceleration for each car A and B, denoted a_A and a_B respectively, when the cars move up a slope with an inclination of 30°.

a_A = ……………..ms^{-2}

a_B = ……………..ms^{-2} [2]

6 (a) (ii) 2. On a road test, Car A enters a slope of 30° at 40 m s^{-1} while Car B enters the slope at 37 m s^{-1} simultaneously at t = 0 s. Using the accelerations calculated in **(a)(ii)1**, draw the velocity-time graphs in the axes provided below for Car A and Car B from t = 0 s to t = 10.0 s. [1]



3. Hence, explain qualitatively whether Car B could overtake Car A at t = 8.0 s.

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6 (b) (i) Two blocks **A** and **B**, each of mass 6 kg and 4 kg respectively, are resting on a compressed spring along a smooth slope as shown in **Fig. 6.1.** The spring constant for the spring is 400 N m^{-1}, and the angle of elevation of the slope is 40˚ above the horizontal.

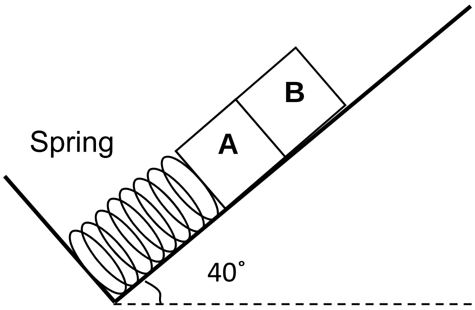


Fig. 6.1

1. Compute the magnitude of the compressive force exerted on the spring due to the blocks.

compressive force = ……………………… N [2]

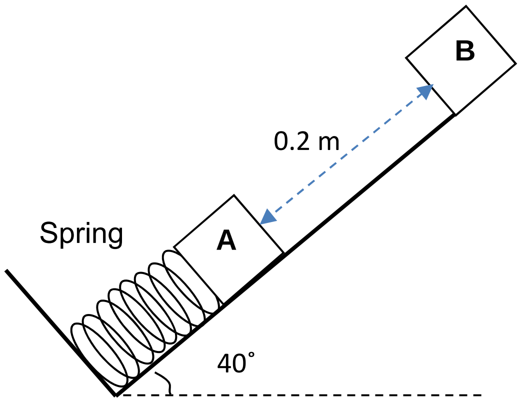
2. Hence, compute the compression of the spring.

compression = ……………………… m [2]

3. Mass B is removed abruptly from the system. Compute the magnitude of the initial acceleration of mass A.

acceleration = ……………………… m s^{-2} [2]

6 (c) (ii) 1. If block B was to be released 0.2 m up the slope while block **A** rested on the compressed spring, what will be the new compression of the spring at the instance where both blocks are momentarily stationary.



New compression of the spring = ……………………………… m [3]

2. Describe qualitatively the subsequent motion of the 2 blocks after the instance of being momentarily stationary.

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7 (a) Define the magnetic field.

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(b) **Fig. 7.1** illustrates a fixed rectangular coil whose lower horizontal side, XY, lies between the poles of a magnet placed on the platform of a top-pan balance.

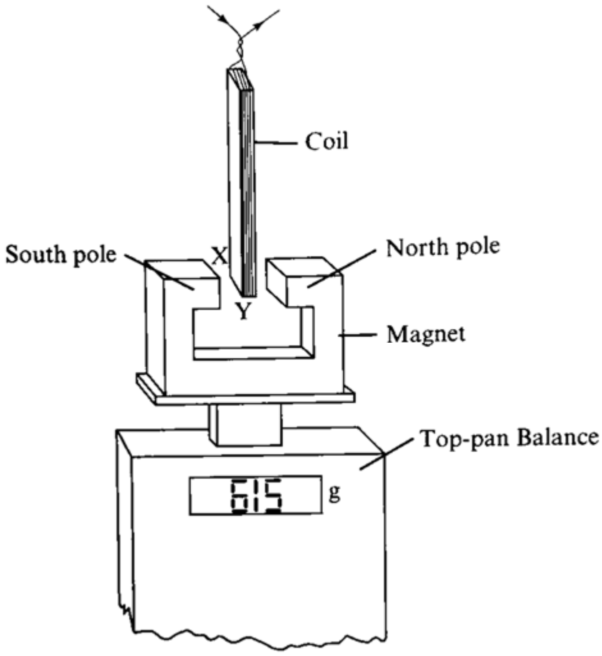

Fig. 7.1

With no current in the coil, the balance records the mass of the magnet. State and explain how the reading of the balance changes when the current is switched on. You may assume a direct current flows from X to Y.

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

(c) In a moving-coil loudspeaker, a circular coil of wire, the speech coil, is free to move in the circular gap between the cylindrical core (South pole) and the surrounding ring (North pole) of a magnet, as shown in **Fig. 7.2.** The speech coil is attached to the speaker cone.

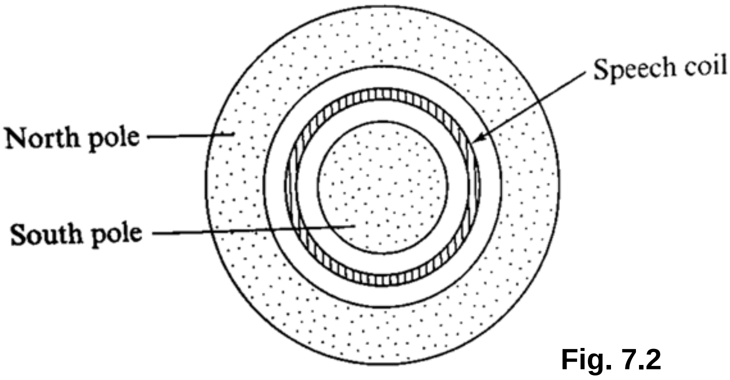

Fig. 7.2

7 (c) (i) The speech coil, with a mean radius of 25 mm, consists of 120 turns of wire. The flux density of the radial field in which the coil lies is 0.45 T. Calculate the electromagnetic force, F, on the coil when a current of 15 mA passes through it.

F =……………….N [2]

(ii) Explain how audio-frequency vibrations of the speaker cone are brought about.

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(d) A student sets up the above apparatus to measure current. Coil X is a circular coil. Square coil Y is pivoted at the centre of Coil X and is free to turn about a horizontal axis AA', in the plane of coil X. When there is no current, the rider is adjusted to make the pointer horizontal.

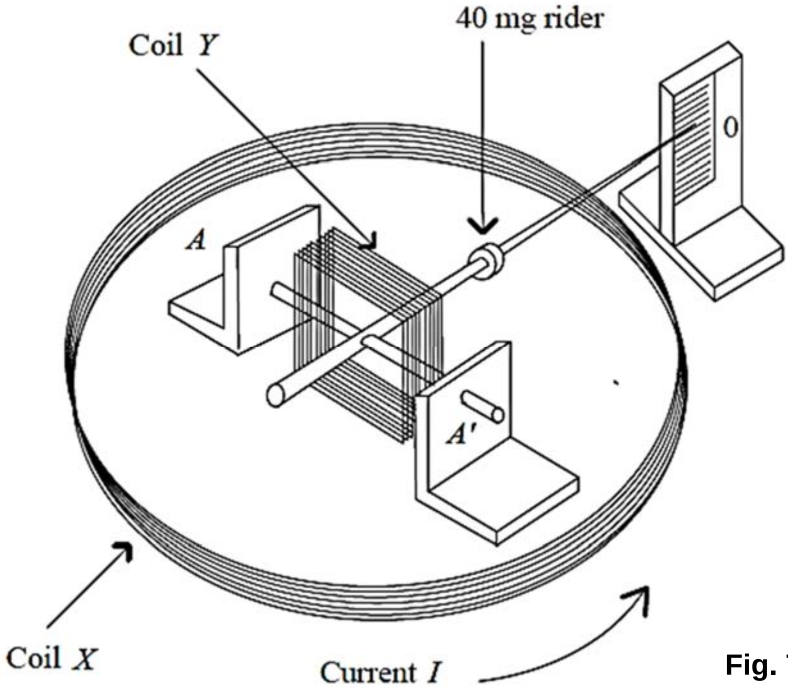

Fig. 7.3

Coils X and Y are connected in series. When a current I flows through the coils, the rider has to be moved 80 mm to the right to restore the pointer to a horizontal position.

(i) In the spaces provided, indicate the direction of the magnetic field produced by coil X at its centre when a current I flows in the direction shown. [1]

(ii) In which direction should the current in Coil Y be flowing? Draw on Fig 7.3, the current direction and the corresponding directions of the forces acting on the 4 sides of Coil Y. [3]

7 (e) Initially, with the switch open, the voltmeter in the circuit of Fig 7.4 below reads 12.0 V. The switch is then closed and the voltmeter reading changes to 11.4 V.

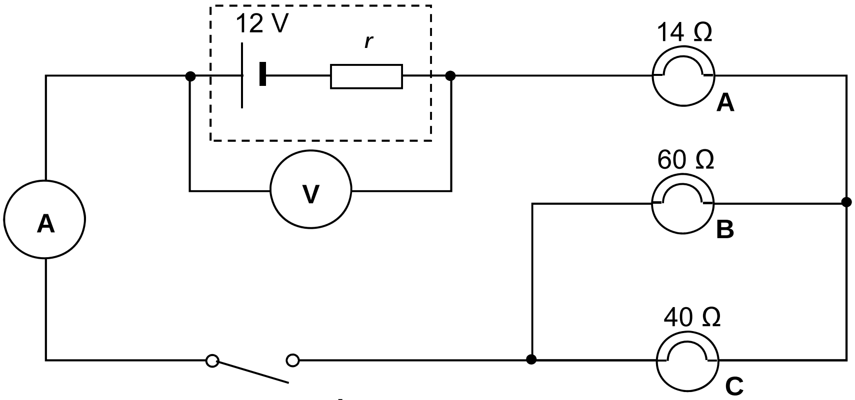

Fig. 7.4

(i) Explain why the voltmeter reading changes when the switch is closed.

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

(ii) Calculate the current flowing through the ammeter.

Current = …………………………A [3]

(iii) Hence, calculate the internal resistance of the battery.

Internal resistance = …………………………Ω [2]

(iv) State and explain, without any further calculations, what happens to the brightness of light bulb **A** and **C** when light bulb **B** is removed from the circuit.

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8 **(a)** The energy levels of two isolated atoms of different elements are shown in Fig. 8.1. The lowest level shown in each diagram corresponds to the ground state.

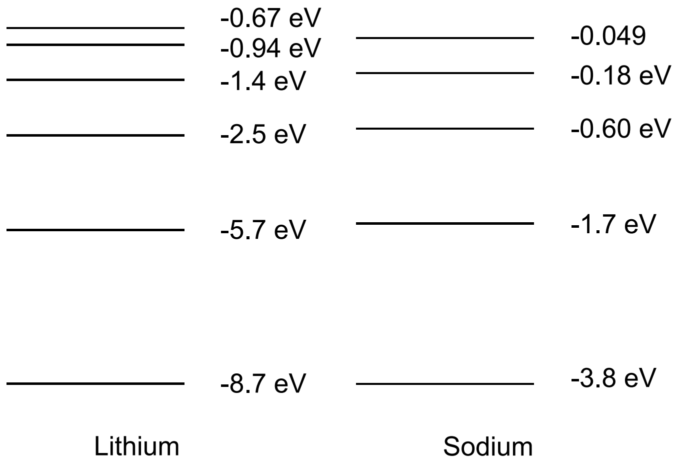

Fig 8.1

(i) The lithium gas was heated up and its light was shone on cooled sodium gas. Explain quantitatively the spectrum which will be observed.

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(ii) The hot lithium gas was replaced with electrons of 3.7 eV. Suggest and explain if there would be any changes in the observed outcome.

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

8 **(b)** When violet light falls on a sheet of barium metal held by an insulating stand for a very long time, the barium acquires a charge. Explain clearly which sign of charge would be acquired.

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(c) Use the theory of the particulate nature of electromagnetic radiation to explain why there is no time delay in emission of photoelectrons for the photoelectric effect.

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(d) Fig. 8.2 is a graph showing the maximum kinetic energy energies of electrons emitted from a metal surface by light of different frequencies from a hydrogen light source.

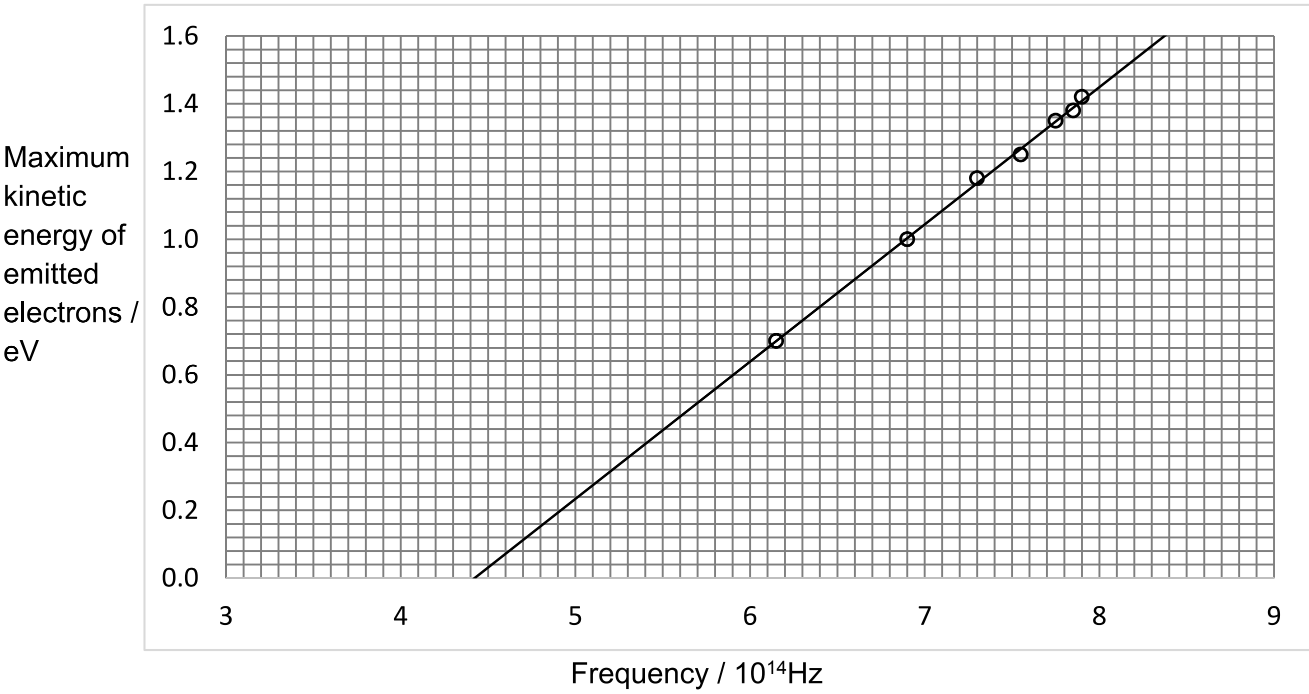

Fig. 8.2

The frequencies of light from the lamp, shown by the small circles on the Fig. 8.2 are the only frequencies obtained in this range. State and explain what can be deduced from the energy levels in hydrogen atoms.

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……[3]

8 (e) Electrons are emitted from a metal surface when light of a particular wavelength is incident on the surface. Explain why the emitted electrons have a range of values of kinetic energy below the maximum kinetic energy of photoelectrons.

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

(f) From experimental observation, electrons of suitable energies are strongly scattered in certain directions by crystalline solid.

(i) Explain why a crystalline solid is required for this experiment.

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(ii) Deduce the nature of the behaviour of electrons from the above experimental observations. Explain clearly why electrons with certain energies could exhibit such behaviour.

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8 **(f)** **(iii)** Accelerated electrons were targeted at a graphite crystal where the carbon atoms are arranged in a hexagonal structure with separation 0.142 nm apart. Estimate the energy of the electrons which can exhibit the behavior describe in **(f)(ii).**

Energy of electron = ……………………… J [2]

-END OF PAPER-