PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS

9646/01

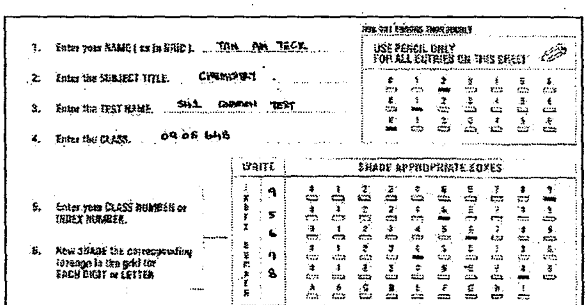
Paper 1 Multiple Choice

31 August 2016

Additional Materials: Multiple Choice Answer Sheet

1 hour 15 minutes

INSTRUCTIONS ON SHADING OF REGISTRATION NUMBER



Shade the index number in a 5 digit format (12345) on the Answer Sheet.

OAS index number is in 5-digit format.

5 digit format: **2nd digit** and the **last four digits** of the Reg Number.

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

This document consists of 18 printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ C$
the Planck constant,	$h = 6.63 \times 10^{-34}\ Js$
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,	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall,	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^2 - x^2}$
resistors in series,	$R = R_1 + R_2 + ...$
resistors in parallel,	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ...$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
Transmission coefficient	$T = \exp(-2kd)$ Where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

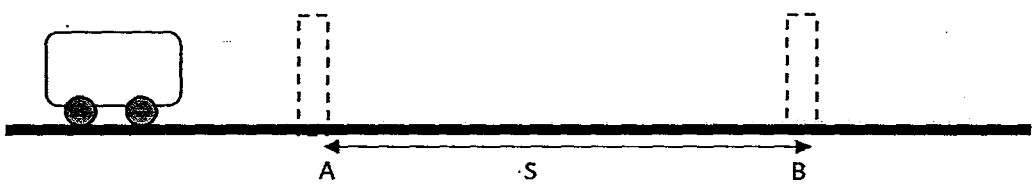
1. The volume of liquid flowing per second is called the volume flowrate Q and has the unit $m^3\ s^{-1}$. The flowrate through a hypodermic needle during an injection can be estimated with the following equation:

$$Q = \frac{\pi R^n (P_2 - P_1)}{8\eta L}$$

The length and radius of the needle are L and R, respectively. The pressure at opposite ends of the needle are P_2 and P_1. The viscosity of the liquid is given by η which has the unit $kg\ m^{-1}\ s^{-1}$. The value of n is

A 2 **B** 3 **C** 4 **D** 8

2. In an experiment to find the constant acceleration of a toy car, the speed of the toy car was captured using speed meters placed at 2 different locations, **A** and **B** respectively.



The distance between **A** and **B** is measured as *S*.
Distance S = 1.400 m ± 0.002 m

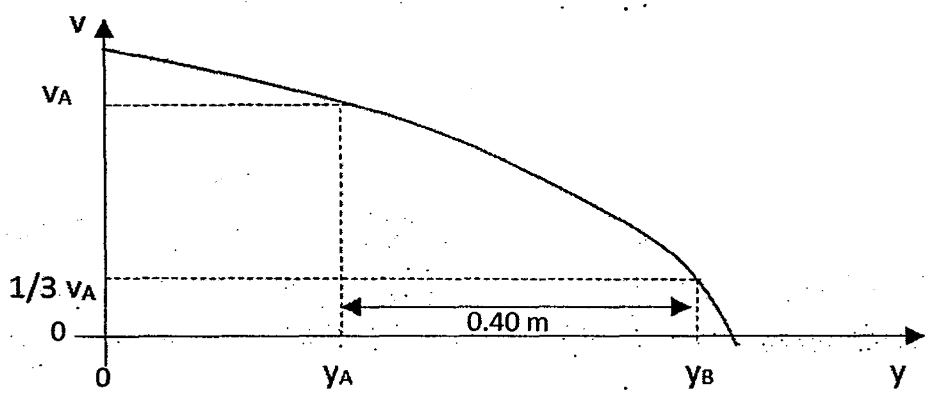
The manufacturer for the speed meter quoted an uncertainty of 1 % for their instrument.
Speed measured at A = 2.50 m s^{-1}
Speed measured at B = 4.65 m s^{-1}

The correct acceleration of the toy car is

A (5.49 ± 0.04) m s^{-2} **B** (5.50 ± 0.04) m s^{-2}

C (5.5 ± 0.4) m s^{-2} **D** (5.5 ± 0.2) m s^{-2}

3. The figure below shows the speed v versus vertical height y of a ball tossed directly upward. The speed at height y_A is v_A. The speed at height y_B is 1/3 v_A. What is the speed v_A?



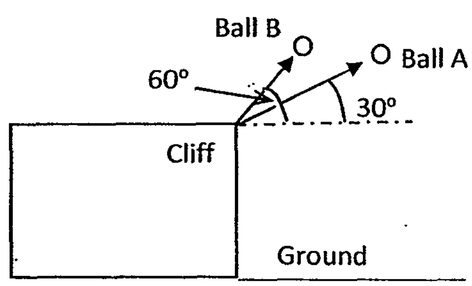
A 2.10 m s^{-1}

B 2.97 m s^{-1}

C 6.98 m s^{-1}

D 9.40 m s^{-1}

4. Two similar balls **A** and **B** were fired at different angles but with the same vertical velocity from the edge of a cliff. Which of the following statements is false?



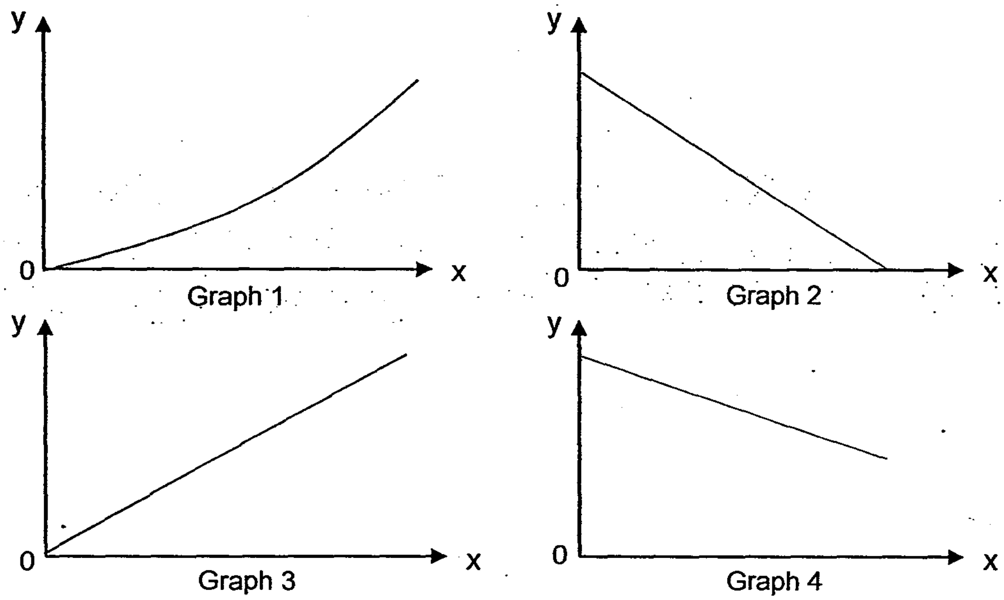
A Both balls will hit the ground at the same time.

B The change in momentum of both balls are the same.

C The ratio of the horizontal velocity of ball **A** to the horizontal velocity of ball **B** is a constant value of $1/\sqrt{3}$.

D The kinetic energy of ball **A**, just before impact with the ground, is greater than ball **B**.

5. An object is projected with a certain velocity at an angle from a flat surface. Which of the following graphs correctly shows the variation of the horizontal displacement with time, and the variation of the kinetic energy with vertical displacement of the object?



	Horizontal displacement vs time	Kinetic energy vs vertical displacement
A	Graph 1	Graph 2
B	Graph 1	Graph 4
C	Graph 3	Graph 2
D	Graph 3	Graph 4

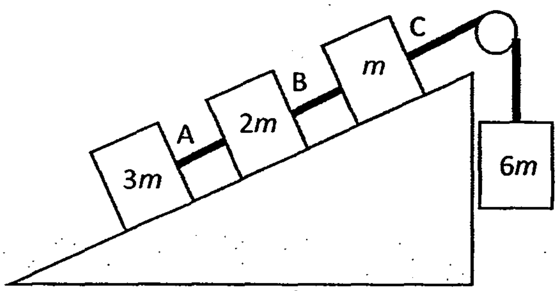
6. Consider two laboratory carts of different masses but both possess identical kinetic energy. Which of the following statements must be correct?

(1) The one with the greatest mass has the greatest momentum
(2) The same impulse was required to accelerate each cart from rest
(3) Both can do the same amount of work as they come to a stop
(4) The same amount of force was required to accelerate each cart from rest

A (1), (4) **B** (2), (3)

C (3), (4) **D** (1), (3)

7. Three blocks of masses $3m$, $2m$ and m are connected to strings **A**, **B** and **C** as shown below. The blocks are placed on a smooth slope surface and attached to a block of mass $6m$ by string **C**. Assuming that the pulley is smooth, which string must be the strongest in order not to break when the block of mass $6m$ is released?



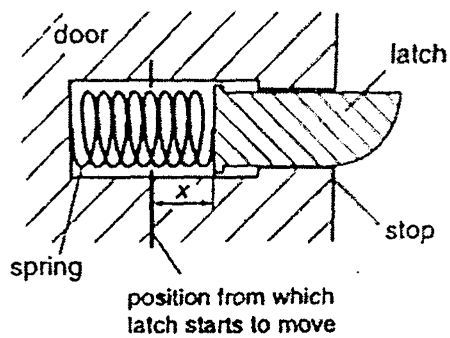
A A

B B

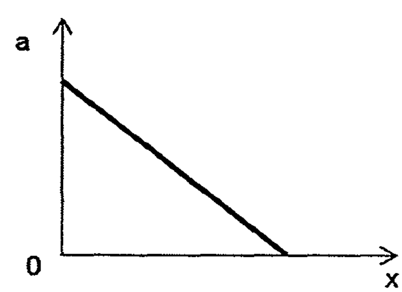
C C

D They must all be the same strength.

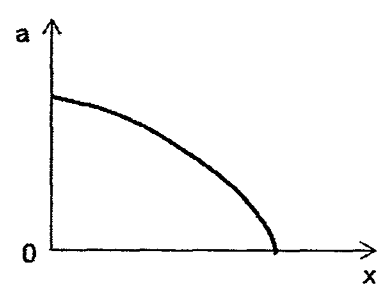
8. A door is fitted with a spring-operated latch as shown. When the latch is pushed in, the spring becomes compressed but remains within its elastic limit. The latch is suddenly released.
Which graph best shows how the acceleration ***a*** of the latch varies with distance ***x*** it moves before it stopped? Ignore friction.



A



B



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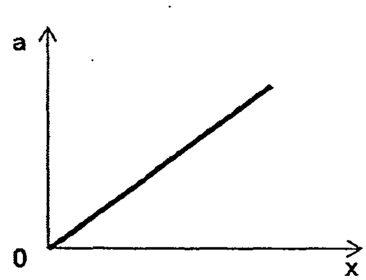
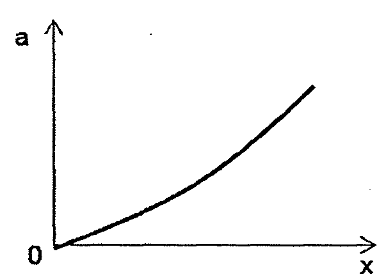


D



9. A child drinks a liquid of density ρ through a vertical straw. Atmospheric pressure is p_o and the child is capable of lowering the pressure at the top of the straw by 10 %. What is the maximum length of straw above the liquid that would enable the child to drink the liquid?

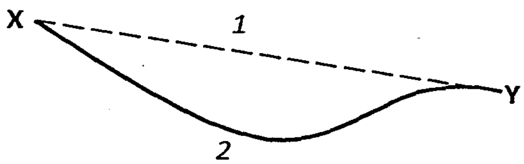
A $\dfrac{p_o}{10\rho g}$

B $\dfrac{p_o}{\rho g}$

C $\dfrac{9p_o}{10\rho g}$

D $\dfrac{10p_o}{\rho g}$

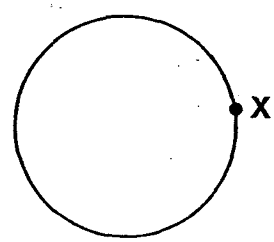
10. Two identical balls were released simultaneously from rest at **X** and made their way to **Y** along two different tracks on the same vertical plane as shown below. Ball 1 travels along a straight down-slope track while ball 2 travels along a curve down-slope followed by an up-slope track. Ball 2 reaches **Y** first.



Neglecting all resistive forces, what can be said of the final energy and the average rate of energy conversion for the two balls?

	Final total energy of	Higher average rate of energy conversion
A	Both balls are the same	Ball 2
B	Ball 2 is higher	Ball 1
C	Ball 2 is higher	Ball 2
D	Both balls are the same	Ball 1

11. A model car moves in a circular path of radius 0.80 m at an angular speed of $2\pi/3$ rad s^{-1}.

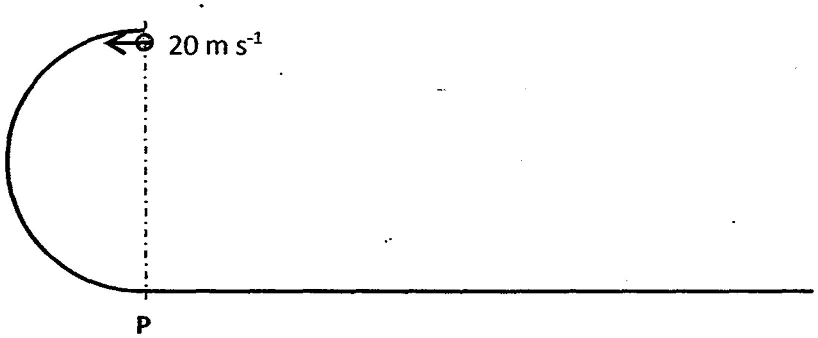


What is its distance travelled from a point **X**, 6.0 s after passing **X**?

A zero **B** 0.8π m

C 1.6π m **D** 3.2π m

12. A rigid track in a plane vertical to the ground consists of a semi-circular section of diameter 5.0 m and a straight horizontal section. A small object with a mass of 100 g is projected horizontally into the track at the top with a speed of 20 m s^{-1}. The track exerts an average resistive force of 1.0 N to the object. Point **P** is vertically below the projection point.



Assuming that the object always stays in contact with the track, calculate the distance from point **P** where the object comes to rest.

A 9.2 m **B** 17.1 m

C 19.9 m **D** 24.9 m

13. A roundabout in a playground rotates uniformly about is vertical axis.

What is the minimum period of rotation of the roundabout, for a girl of 40 kg to stay on safely, if she was standing 2.0 m from the vertical axis as the roundabout rotates?

Frictional force on girl due to the surface of roundabout, $F = 1.16\ W$, where W is the weight of the girl.

A 2.2 1 s **B** 2.38 s **C** 2.63 s **D** 6.94 s

14. The radius of the Earth is R and X is a point $4R$ from the surface of the Earth. When a stationary object of mass m falls from X towards the Earth, which of the following statement is false? The mass of Earth is M.

A The speed of impact is $\sqrt{\frac{8GM}{5R}}$

B The work done by the gravitational field is $\frac{0.8\ GMm}{R}$.

C The change in the magnitude of gravitational field strength is $\frac{0.96\ GM}{R^2}$.

D The change in gravitational potential is $\frac{0.8\ GM}{R}$.

15. A satellite is put in circular orbit about Earth with a radius equal to half of the radius of the Moon's orbit. Given that the period of revolution of the Moon is T, what is the period of the satellite's revolution in terms of T?

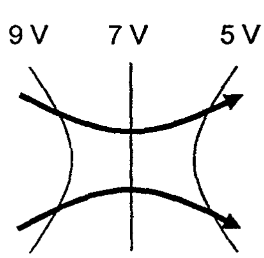
A $\frac{T}{8}$

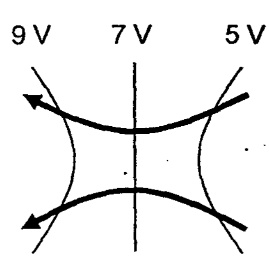
B $\frac{T}{2\sqrt{2}}$

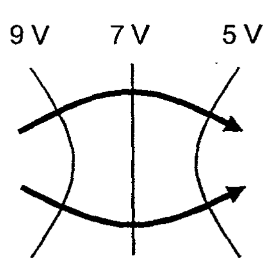
C $\frac{T}{2}$

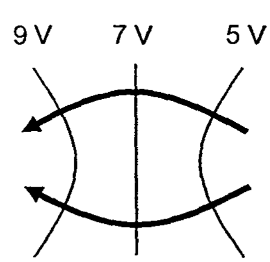
D $2\sqrt{2}\ T$

16. In the diagrams, the thin lines show equipotential lines and the bold arrows show the electric field lines and their directions. Which set of equipotential lines and field lines is possible?

A


B


C


D


17. A jet of steam at 100 °C is directed into a hole in a large block of ice of 0 °C. After the steam has been switched off, the condensed steam and the melted ice are both at 0 °C. The mass of water collected in the hole is 206 g. Calculate the mass of ice melted.
Specific heat capacity of water = 4200 J kg^{-1} K^{-1}
Specific latent heat of vaporisation of water = 2260 kJ kg^{-1}
Specific latent heat of fusion of water = 330 kJ kg^{-1}

A 22.5 g　　**B** 26.2 g

C 179.8 g　　**D** 183.5 g

18. An ideal monatomic gas has 1000 J of heat added to it and it does 500 J of work; its temperature changes by T_1. When twice the amount of heat is added to it and it does the same amount of work, its temperature changes by T_2. The ratio of T_1 / T_2 is

A 1/5　　**B** 1/3　　**C** 3/5　　**D** 1

19. A particle oscillates with simple harmonic motion. Which of the following statements about the acceleration of the oscillating particle is true?

A It is least when the speed is greatest.

B It is always in the opposite direction to its velocity.

C It is proportional to the frequency of the wave.

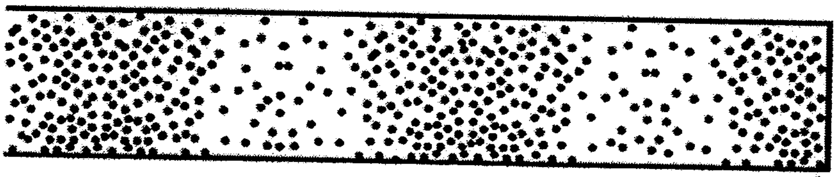
D It decreases as the potential energy increases.

20. A loudspeaker emits a sound wave of amplitude A and intensity I. After some time, the intensity increased by 8.00 %. The corresponding change in amplitude is

A 3.92 %　　**B** 16.6 %

C 104 %　　**D** 108 %

21. The diagram below shows the positions of the air particles for an open-closed tube at the instant when time $t = 0$ s.



Which of the following statements is NOT correct?

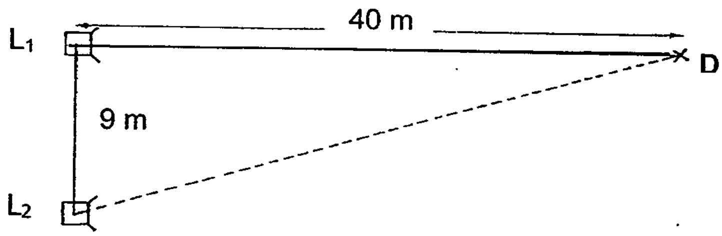
A At the instant $t = 0$ s, the air pressure variation is maximum but the air velocity is zero at the closed end.

B There will always be more than 2 complete wavelengths in the tube at any instant in time.

C At the instant $t = T/4$, the air pressure variation is zero but the air acceleration is maximum at the open end.

D The frequency of the air particles is 9 times the value of the fundamental frequency.

22. Two loudspeakers L_1 and L_2, driven by a common oscillator and amplifier, are set up as shown. As the frequency of the oscillator increases from zero, the detector at **D** recorded a series of maximum and minimum signals. At what frequency is the first **minimum** observed?
(Speed of sound = 330 m s^{-1})

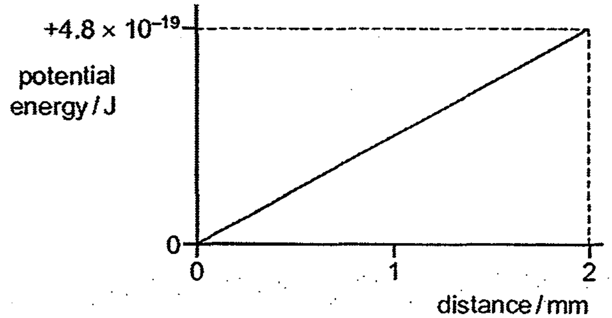


A 165 Hz B 330 Hz C 495 Hz D 660 Hz

23. A beam of light of wavelength λ is incident normally on a diffraction grating. The angular separation between the two second order maxima is θ. The resolution of the grating is d. Which row corresponds to the correct values of λ, θ and d?

	λ	θ	d
A	710 nm	60°	3.5 x 10^5 lines per metre
B	710 nm	30°	1.5 x 10^5 lines per metre
C	420 nm	60°	3.5 x 10^5 lines per metre
D	420 nm	30°	1.5 x 10^5 lines per metre

24. Two parallel plates **R** and **S** are 2.0 mm apart in a vacuum. An electron moves along a straight line in the electric field between the plates. The graph shows how the potential energy of the electron varies with its distance from plate **R**.



Which of the following statements is false?

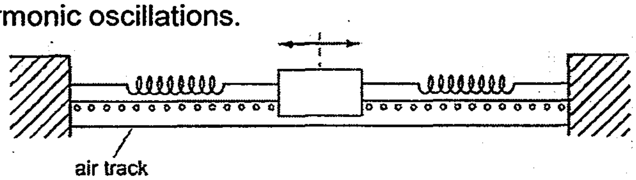
A The electric field between **R** and **S** is uniform.

B The electric field strength is 3000 N C^{-1}.

C The force on the electron is constant.

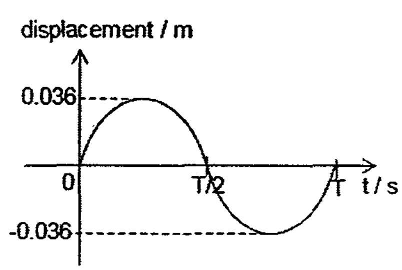
D The magnitude of the potential difference between **R** and **S** is 3.0 V.

25. A linear air track vehicle of mass 2.0 kg held centrally on an air track by two springs makes simple harmonic oscillations.

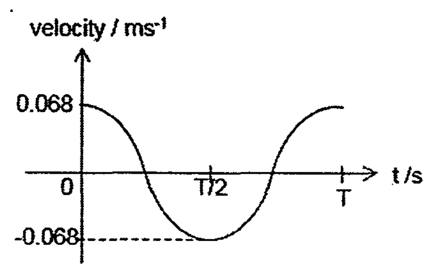


When its displacement from equilibrium is 0.020 m, it speed is 0.030 m s^{-1}.
When its displacement from equilibrium is 0.030 m, it speed is 0.020 m s^{-1}.
Assuming at t = 0, the vehicle is at the equilibrium position, which one of the following graph must be wrong because it does not correspond with the others?

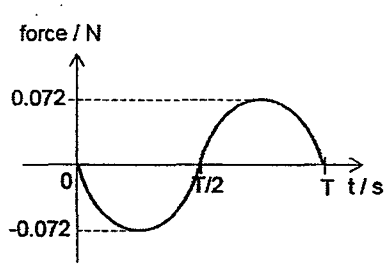
A



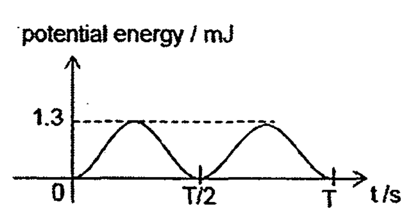
B



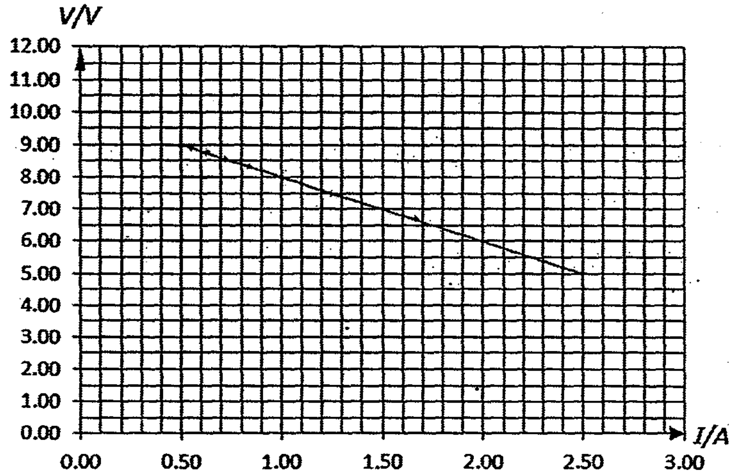
C

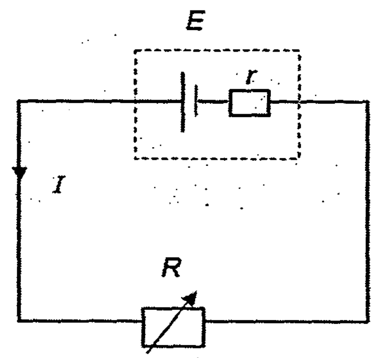


D



26. A battery of e.m.f. E, with internal resistance r, is connected in series with a variable resistor R (refer to circuit diagram). The figure below shows the variation of the terminal p.d V to the current I in the circuit as R is varied. Which of the following statement is false?





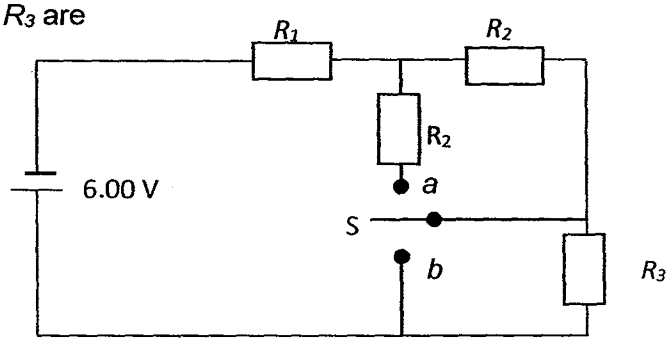
A The internal resistance r is 2.0 Ω.

B When the current in the circuit is 2.50 A, the resistor R is 4.0 Ω .

C The e.m.f of the battery E is 10 V.

D When the R = 50 Ω, the power dissipated in the resistor R is 1.85 W.

27. A 6.00 V battery supplies current to the circuit shown in the figure below. When the double-throw switch **S** is open as shown in the figure, the current in the battery is 1.00 mA.
When the switch is closed in position a, the current in the battery is 1.20 mA. When the switch is closed in the position b, the current in the battery is 2.00 mA. The resistances of R_1, R_2, R_3 are



	R_1/ Ω	R_2/ Ω	R_3/ Ω
A	2000	1000	3000
B	1000	2000	3000
C	3000	1000	2000
D	3000	2000	1000

28. A small plastic sphere carrying a positive charge is maintained at a constant height by the action of an upward vertical electric field.

A uniform magnetic field is applied in the same direction as the electric field.

What does the sphere do?

A Move downwards in a spiral path.

B Move in a horizontal circle.

C Move upwards in a spiral path.

D Remain stationary.

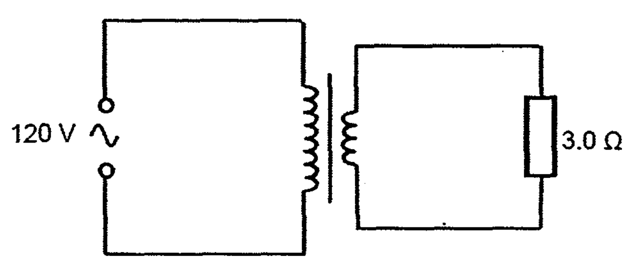
29. A mains electricity supply has a root-mean-square voltage of 240 V and a peak voltage of 340 V. When connected to this supply, a heater dissipates energy at a rate of 1000 W. The heater is then connected to a 340 V d.c. supply and its resistance remains the same.

At what rate does the heater now dissipate energy?

A 1000 W **B** 1400 W

C 2000 W **D** 2800 W

30. A transformer is use to step down 120 V a.c. voltage supply to a 3.0 Ω resistive load. The ratio of the secondary turns to the primary turns is 1:20. What is the current in the primary coil?



A 40 A **B** 6.0 A **C** 2.0 A **D** 0.10 A

31. Diagram 1 shows an aluminium rod, moving at right angles to a uniform magnetic field. Diagram 2 shows the variation with time t of the distance s from **O**.

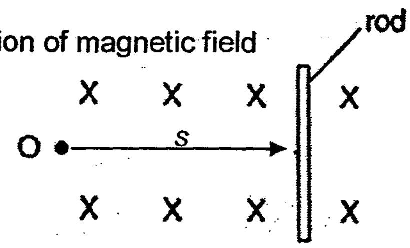


Diagram 1

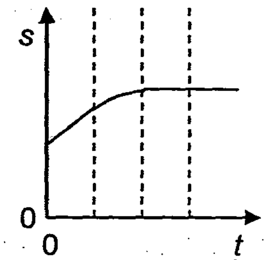
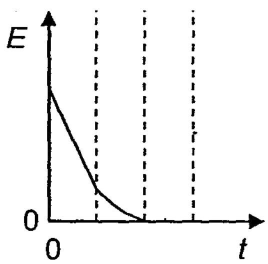


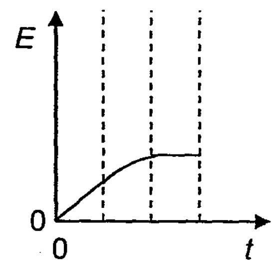
Diagram 2

Which graph best shows the variation with time t of the e.m.f. E induced in the rod?

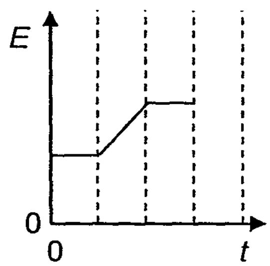
A



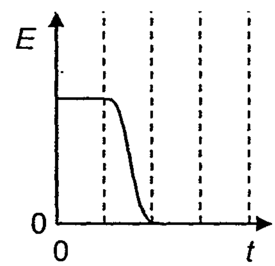
B



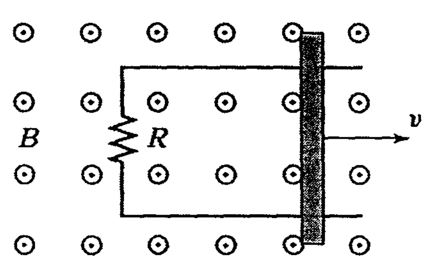
C



D



32. An external force F is exerted on a conducting bar which moves to the right with constant velocity v in a uniform magnetic field B that points out of the page. The conducting rod has negligible internal resistance.



Which of the following statements is most likely correct?

A The current in the conducting bar flows from higher potential to lower potential.

B F must be increasing to ensure that the conducting bar moves with constant velocity.

C If F is constant, the power of the resistor is approximately Fv.

D The current in the conducting bar will increase if B decreases.

33. Which one of the following has the largest energy content?

A 10^2 photons of wavelength 1 pm (γ-rays)

B 10^5 photons of wavelength 2 nm (X-rays)

C 10^6 photons of wavelength 5 μm (infra-red radiation)

D 10^8 photons of wavelength 600 nm (yellow light)

34. Of the following phenomena, which provides the best evidence that particles can have wave properties?

A The absorption of photons by electrons in an atom.

B The interference pattern produced by neutrons incident on a crystal.

C The production of x-rays by electrons striking a metal target.

D The scattering of photons by electrons at rest.

35. The speed of a moving electron is measured to be 1.95×10^6 m s^{-1}, to a precision of 0.50 %. What is the minimum uncertainty with which its position can be simultaneously measured?

A 5.9×10^{-9} m

B 5.9×10^{-11} m

C 5.4×10^{-39} m

D 5.4×10^{-41} m

36. Which of the following statements below on intrinsic semiconductors is true?

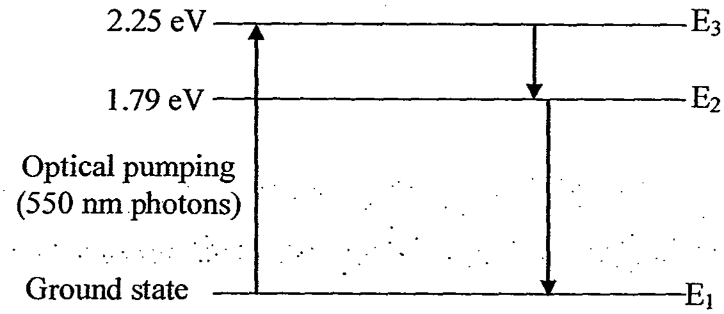
A The total current flow is due to the movement of the electron-hole pair.

B The valence band is completely filled and the conduction band is partially filled.

C There are more electrons in the conduction band than there are holes in the valence band.

D The valence band is completely filled and the conduction band is empty at room temperature.

37. In a ruby laser, light of wavelength 550 nm from a xenon flash lamp is used to excite the chromium (Cr) atoms in the ruby from ground state E_1 to state E_3. In subsequent de-excitations, laser light is emitted. Which of the following statements regarding this laser is **incorrect**?



A E_3 cannot be the metastable state because, if it is, then there will be no net production of light when equilibrium is reached, since stimulated absorption and stimulated emission will then occur at the same rate because the numbers of electrons in E_3 and E_1 will be the same at steady state.

B E_3 is the metastable state because, having a longer lifetime than a normal excited state, the metastable state allows the accumulation of excited electrons, resulting in population inversion and net light production.

C E_2 is the metastable state because it is not subject to stimulated emission caused by the 550 nm photons used in optical pumping, and so allows the accumulation of excited electrons to achieve population inversion.

D The transition from state E_2 to E_1 produces the laser light.

38. Which of the following statements concerning nuclear properties is true?

A The greater the binding energy of a nucleus, the more stable it is.

B If the total rest mass of the products of a reaction is greater than the total rest mass of the reactants, this reaction is impossible.

C The half-life of a radioactive substance can be changed by allowing the substance to react chemically to produce a new radioactive compound.

D When a stationary nucleus decays by emitting a γ-photon, the nucleus will move off in an opposite direction to the photon.

39. A radioactive nuclide **M** undergoes a series of decays to form **N**, which is an isotope of **M**. **M** most likely had undergone

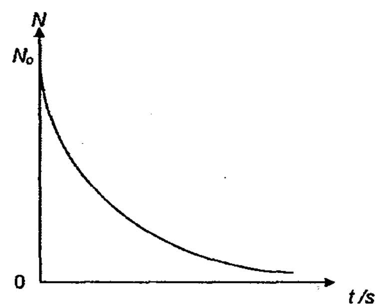
A 10 alpha and 5 beta decays

B 11 alpha and 11 beta decays

C 12 alpha and 4 beta decays

D 13 alpha and 26 beta decays

40. The figure (not to scale) below shows the variation with time t of the number of active nuclei N of a sample of radioactive nuclide. The initial number of nuclei is N_o. The half-life is $\ln(2^3)$ s.



Consider a tangent, **m,** to the curve drawn at the point N_o. **m** will cut the t-axis at

A $\frac{3}{\ln 2}$ s

B $\frac{3}{2\ln 2}$ s

C $\frac{3}{\sqrt{2}\ln 2}$ s

D $\frac{3\ln 2}{\ln 2}$ s

END of PAPER

Preliminary Examinations
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9646/02**
Paper 2 Structured Questions
Candidate answers on the Question Paper.

26 August 2016
1 hour 45 minutes

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.
Answers **all** questions.

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
Total (72m)	

This document contains 17 printed pages, including this cover page.

Data

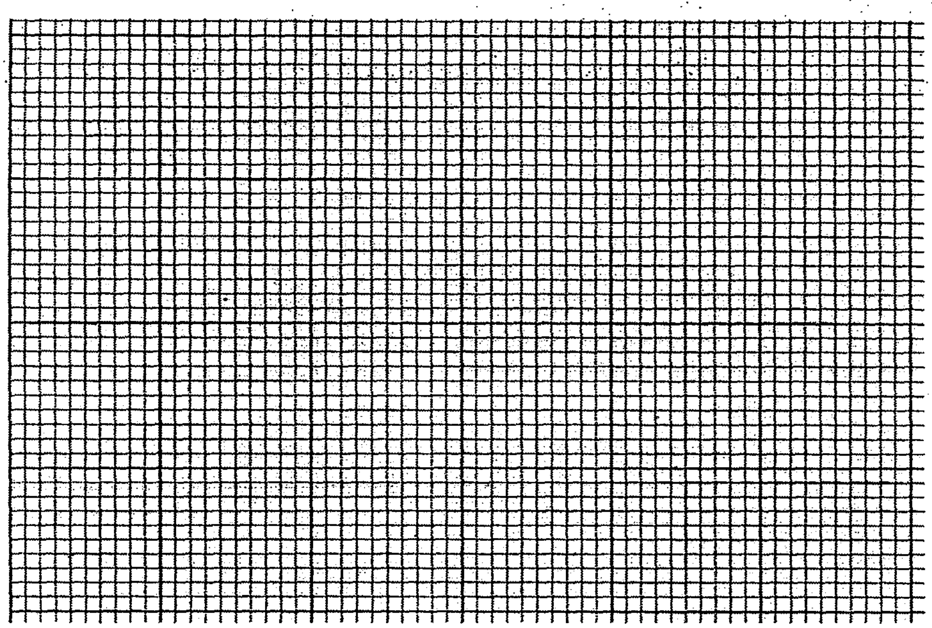
speed of light in free space,	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ C$
the Planck constant,	$h = 6.63 \times 10^{-34}\ Js$
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,	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall,	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2,\ v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^{\ 2} - x^2}$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
Transmission coefficient	$T = \exp(-2kd)$ Where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1(a) 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 27.8 m s^{-1} in 3.5 s while car B can accelerate uniformly from rest to 27.8 m s^{-1} in 4.0 s.

(i) 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]



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

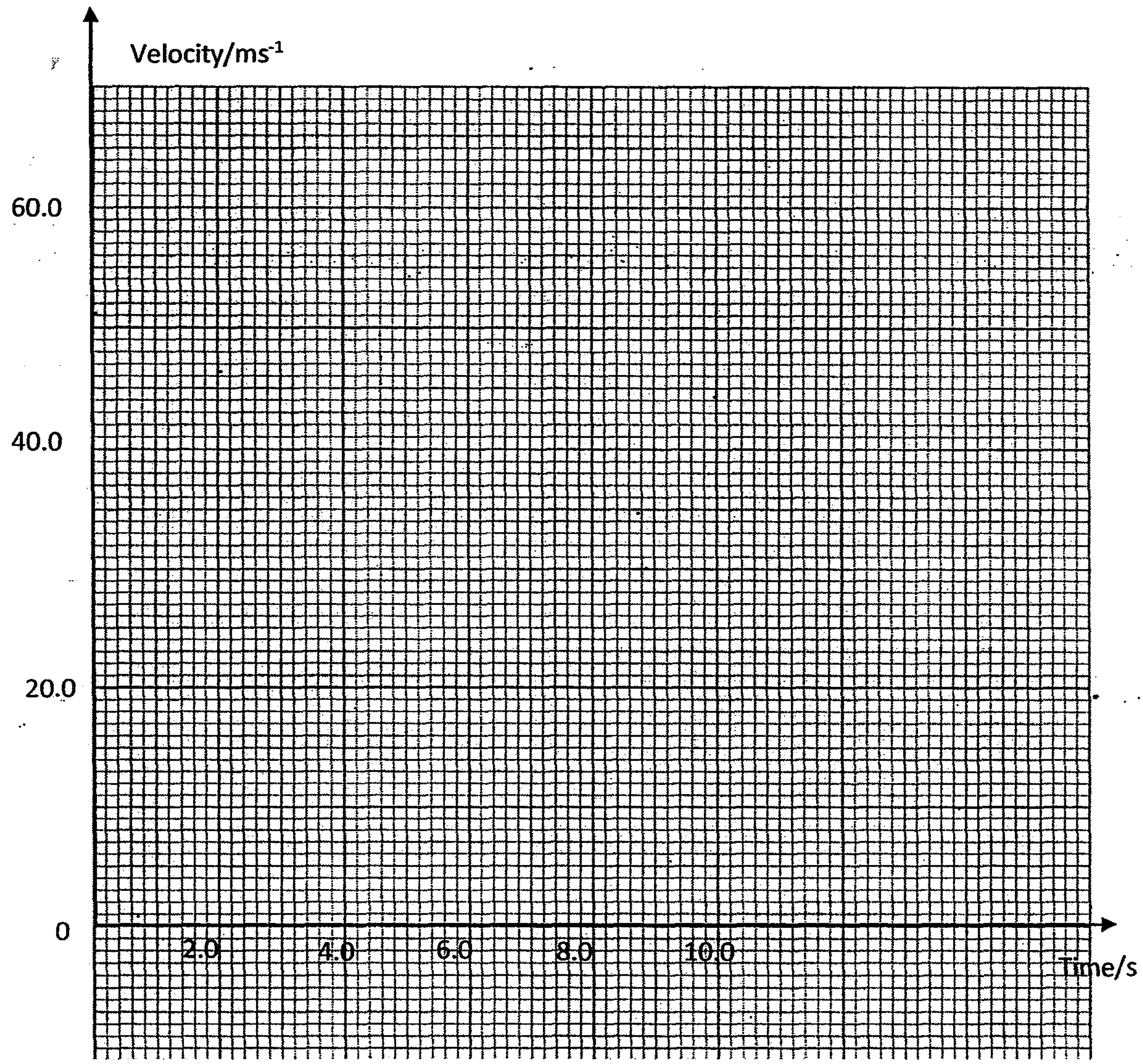
d =................m [2]

(b) (i) 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° with the horizontal.

a_A = ...m s^{-2}

a_B = ...m s^{-2} [2]

1(b) (ii) 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 **1(b)(i)**, 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]



(iii) Hence, explain qualitatively whether car B could overtake car A at t = 8.0 s.

....

....

....

....[2]

2 (a) **(i)** An object, immersed in a liquid in a tank, experienced an upthrust. Explain briefly the physical reason for this upthrust.

....

.... [1]

(ii) A thin plastic bag is found to have a mass m when empty and pressed flat. When the bag is filled with air, of volume V and density ρ, at atmospheric pressure and re-weighed, state and explain what would be the measured weight of the bag.

....

....

....

.... [3]

(b) Consider a person bending as shown in Fig. 2.1. The force diagram for the spine of the person, with the back horizontal, can be shown in Fig. 2.2.

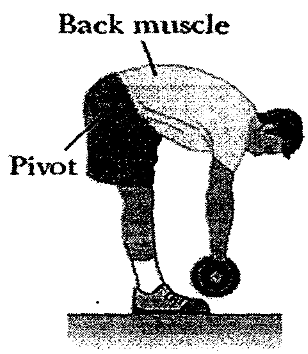


Fig. 2.1

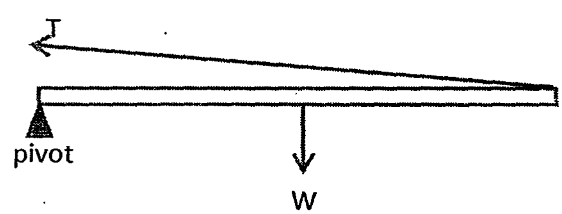


Fig. 2.2

The spine can be considered as a rod pivoted at its base. The various muscles of the back are equivalent to a single muscle producing a force T as shown. W is the force that the upper part of the body exerts on the spine.

(i) State and explain qualitatively the value of T, relative to W, at equilibrium.

....

....

.... [2]

(ii) On Fig. 2.2 , draw a force, F, at the pivot which is necessary for equilibrium. Hence, state and explain qualitatively the value of F, relative to W.

....

.... [2]

3 **(a)** Explain:

(i) what is meant by a plane-polarised wave;

....

.... [1]

(ii) why sound waves cannot be polarised.

....

.... [1]

(b) Figs. 3.1 and 3.2 show an experiment in which a student observes two parallel beams of light through a Polaroid filter. In Fig. 3.1, the beam consists of unpolarised light of intensity I_o. In Fig. 3.2, the beam is plane-polarised with intensity I_1.

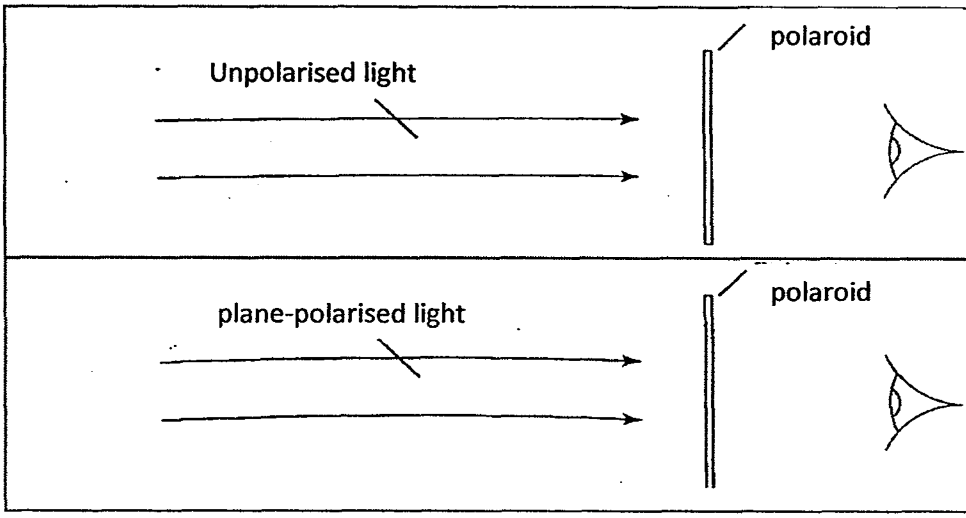
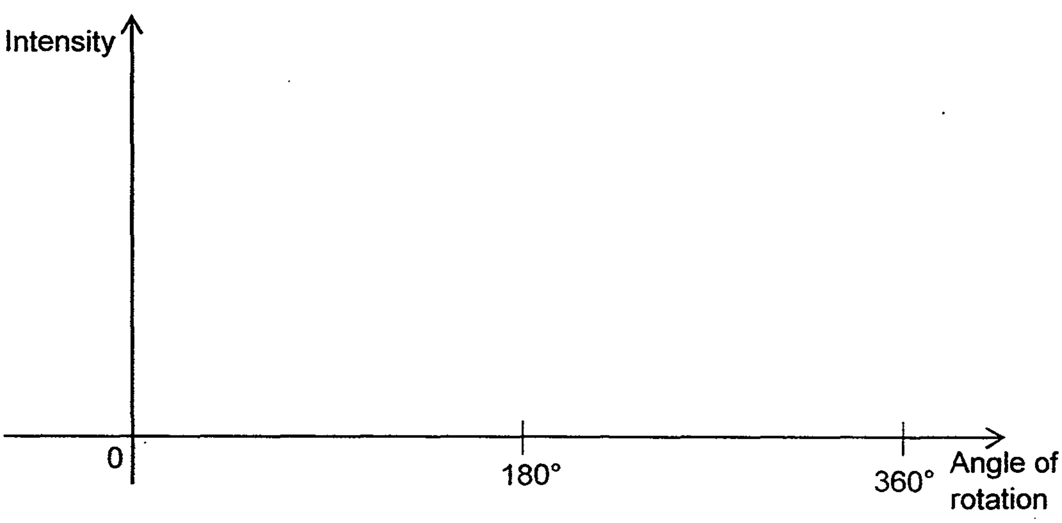


Fig. 3.1

Fig. 3.2



On the axes above, sketch two graphs, labelled **(1)** and **(2),** corresponding to Fig. 3.1 and Fig. 3.2 respectively, to show how you might expect the intensity of the light reaching the student to vary as the polaroid in each case is turned 360° in its own plane. [2]

(c) Light from a low pressure sodium lamp consists mostly of two wavelengths, 589.99 nm and 589.59 nm. This light is allowed to fall normally on a diffraction grating with 500 lines per millimetre. Describe quantitatively the pattern which would be observed.

[2]

4 (a) Fig. 4.1 shows how the electric potential, V, varies with $\frac{1}{r}$, where r is the distance from a point charge Q.

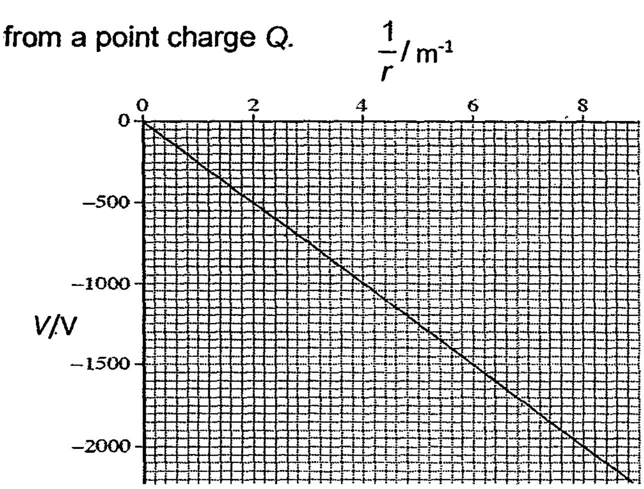


Fig. 4.1

State what can be deduced from the graph about how V depends on r and explain why all the values of V on the graph are negative.

....

....

....[2]

(b) Two positively charged metal spheres A and B are situated in a vacuum, as shown in Fig. 4.2.

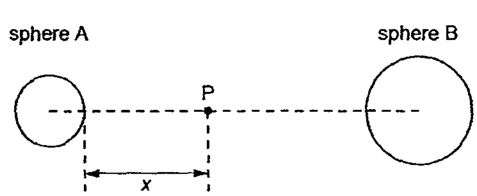


Fig. 4.2

A point P lies on the joining the centres of the two spheres and is a distance *x* from the surface of sphere A.

The variation with *x* of the electric potential *V* due to the two charged spheres is shown in Fig. 4.3.

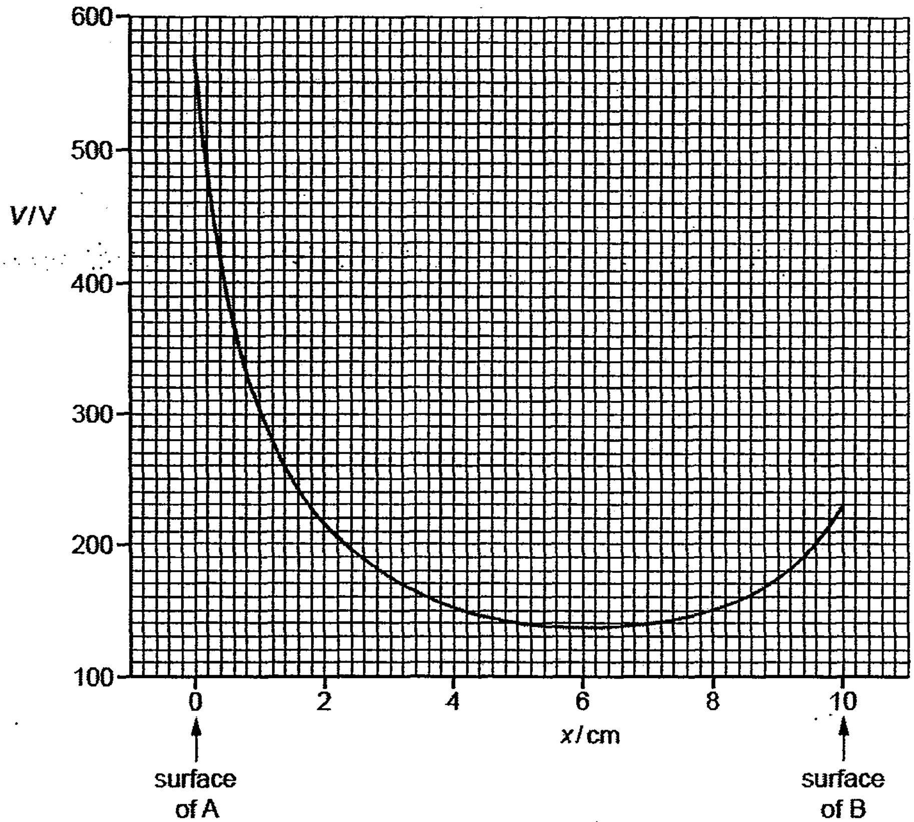


Fig. 4.3

(i) State how the magnitude of the electric field strength at any point may be determined from the graph of Fig. 4.3.

....

.... [1]

(ii) Without any calculations, describe the force acting on a positively charged particle placed at point P for values of x from x = 0 to x = 10 cm.

....

....

....

.... [3]

(c) The positively charged particle in **(b)(ii)** has charge q and mass m given by the expression

$$\frac{q}{m} = 4.8 \times 10^{7}\ \mathrm{Ckg^{-1}}$$

Initially, the particle is at rest on the surface of sphere A where $x = 0$. It then moves freely along the line joining the centres of the sphere until it reaches the surface of sphere B.

Calculate the speed, v, of the particle as it reaches the surface of sphere B. Explain your working.

v = ...ms^{-1} [2]

5 (a) Fig. 5.1 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.

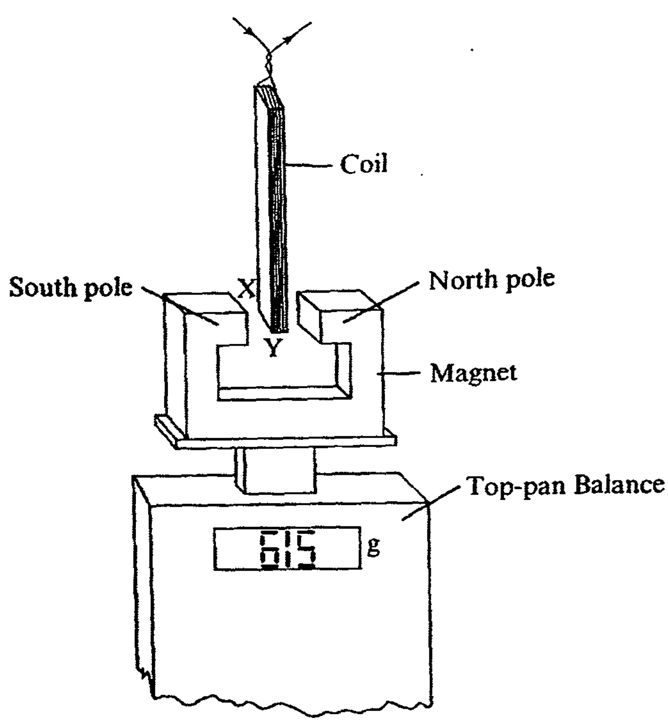


Fig. 5.1

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.

....

....

....[2]

(b) 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. 5.2. The speech coil is attached to the speaker cone.

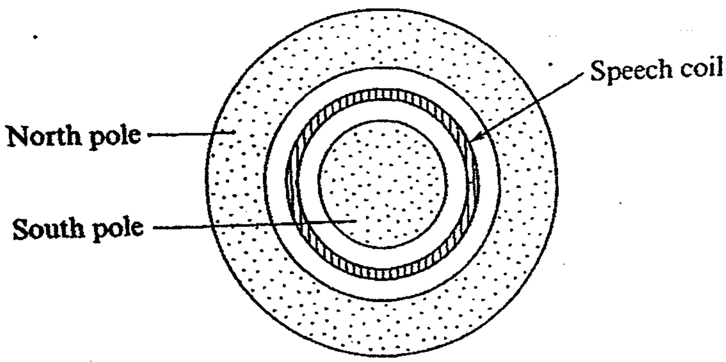


Fig. 5.2

(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.

....

....

....[2]

6 (a) Fig. 6.1 shows the variation of intensity I with wavelength λ of a typical X-ray spectrum.

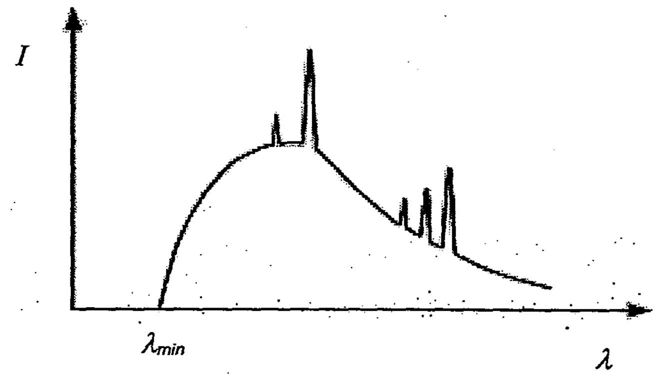


Fig. 6.1

By reference to the principles of production of X-rays in an X-ray tube, explain the origins of any two main features of the spectrum using quantum theory.

....

....

....

....

....

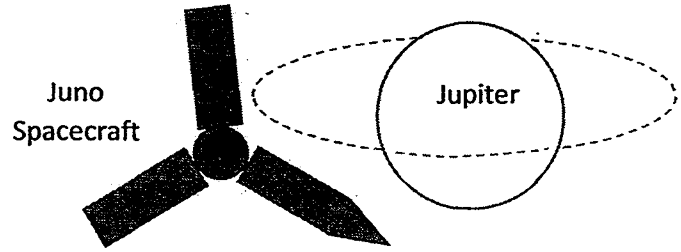
....[3]

(b) Suppose the ionisation energy of an atom is 4.10 eV. In the spectrum of this same atom, we observe emission lines with wavelengths 310 nm, 400 nm, 1378 nm.

Use this information to construct the energy-level diagram with the fewest levels. Assume the higher levels are closer together.

[4]

7 It was reported on 6 July 2016 in the news that NASA's Juno spacecraft reached the desired orbit around Jupiter. The mission was to find out more about Jupiter.



Jupiter has many moons. Fig.7.1 shows the period and orbital distance of some of the moons found around Jupiter.

Moon	Period, T/Days	Orbital Distance, r/10^8 m
Metis	0.295	1.28
Unknown	0.38	1.85
Thebe	0.67	2.22
Io	1.77	4.22
Europa	3.55	6.71
Ganymede	7.16	10.7
Callisto	16.7	18.8

Fig.7.1

(a) The variation with orbital distance r of the period T is given by the expression

$$T = kr^{m/n}$$

(i) Theory suggest that m/n = 1.5. Use Fig.7.1 to show that the data supports this suggestion. [2]

(ii) A graph of some of the data showing the variation of lg (T/days) with lg (r/m) is shown in Fig.7.2.

On Fig 7.2,

1. Plot the point corresponding to r = 4.22 x 10^8 m,
2. Draw the line of best fit for all the points. [2]

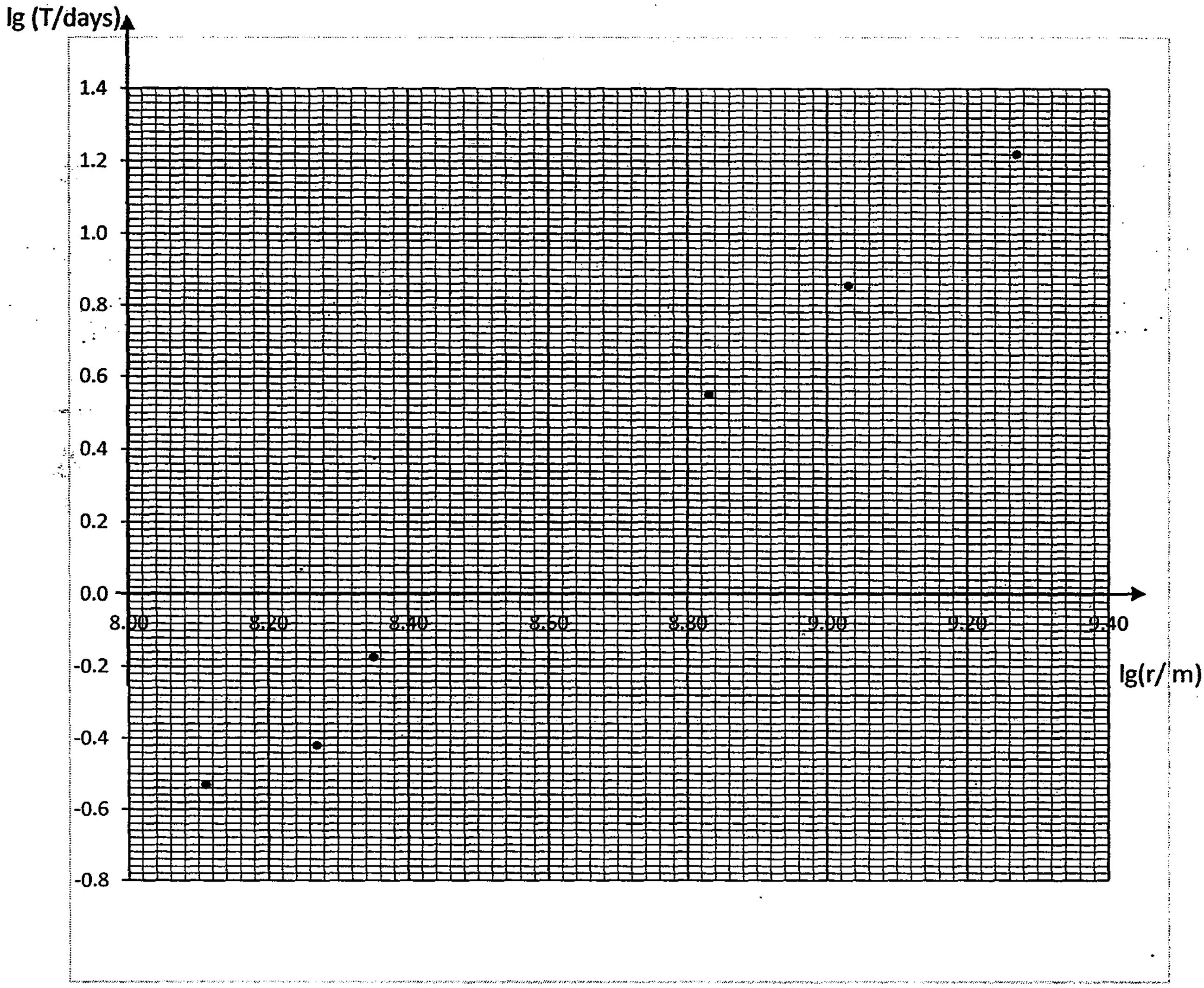


Fig. 7.2

(iii) Determine the gradient of the line you have drawn on Fig.7.2.

Gradient = ... [2]

(iv) Explain why the graph of Fig.7.2 supports the expression given in **7(a).**

....

....[2]

(v) State values of the integer m and n.

m =................ and
n=.................. [1]

(vi) Given $k = \sqrt{\frac{4\pi^2}{GM}}$ where M is the mass of Jupiter, determine the mass of Jupiter.

M = ...kg [2]

(b)(i) **1.** The intensity of sunlight from the Sun reaching Earth is about 1400 W m^{-2}. Jupiter is 5.2 times the distance from the Earth to the Sun. Show that the intensity of the Sunlight reaching Jupiter is about 50 W m^{-2}. [1]

2. It was reported that the Juno's Solar array of 60 m^2 can produce about 500 W of power. Calculate the efficiency of the Solar array on Juno's spacecraft.

Efficiency =.........%[2]

(ii) Juno Spacecraft passed through Jupiter's north pole where it encountered radiation of high speed electrons. Its crucial system was shielded by a titanium vault. Suggest a reason for the need to shield the Juno's spacecraft system from the high speed electrons.

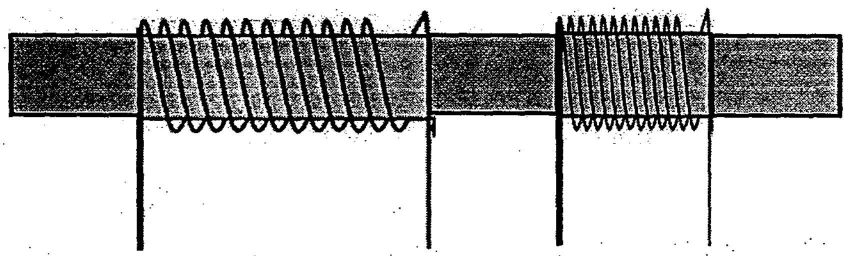
....

....

....

....[2]

8 A simple transformer can be made by winding coils of copper wire around a solid hard iron core.



It is suggested that the efficiency of such a transformer can be affected by the power supplied to it.

Design an experiment using a simple transformer to find out how the efficiency of the transformer varies with the frequency of the power supply. You should draw a labelled diagram to show the arrangement of your apparatus. In your account, you should pay particular attention to

(i) the identification and control of variables,
(ii) the procedure to be followed
(iii) how the efficiency is calculated
(iv) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram:

[12]

End of Paper

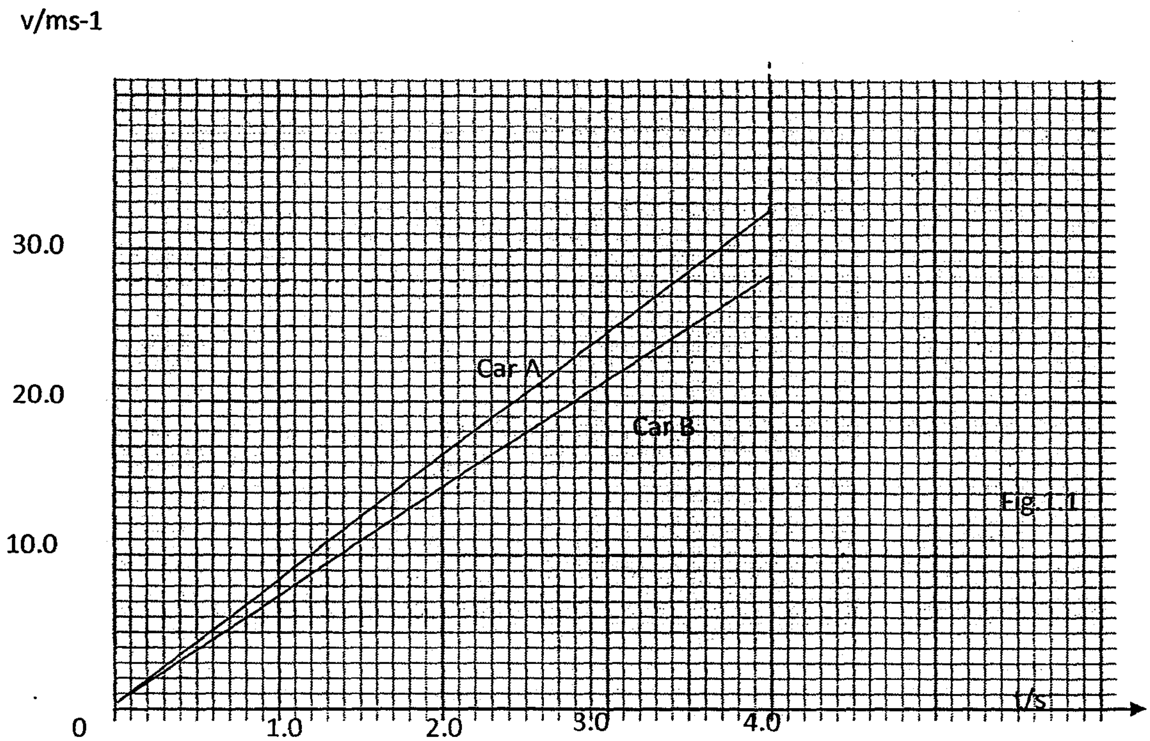
2016 H2 Physics Prelim Suggested Solutions

Paper 1

1	C	11	D	21	C	31	D
2	D	12	B	22	A	32	C
3	B	13	C	23	A	33	D
4	C	14	D	24	B	34	B
5	D	15	B	25	B	35	A
6	D	16	C	26	B	36	A
7	C	17	D	27	B	37	B
8	A	18	B	28	D	38	D
9	A	19	A	29	C	39	D
10	A	20	A	30	D	40	D

Paper 2

1 (a)(i)



[2]

1 (a)(ii) Distance travelled by car A = ½ x 4.0 x 32.0 = 64.0 m

Distance travelled by car B = ½ x 4.0 X 27.8 = 55.6 m

Distance between the cars = 64.0 - 55.6 = **8.4 m**

1 (b)(i) Acceleration of car A, $a_A = 27.8/3.5 = 7.94$ ms^{-2}

Acceleration of car B, $a_B = 27.8/4.0 = 6.95$ ms^{-2}

Effective acceleration of car A = $a'_A = (a_A \times 0.8) - g\sin 30°$

$= 7.94 \times 0.8 - 9.81\ (0.5)$

$= 1.447 =$ **1.45 m s^{-2}**

Effective acceleration of car B = $a'_B = a_B - g\sin 30°$

$= 6.95 - 9.81\ (0.5) = 2.045 =$ **2.05 m s^{-2}**

1 (b)(ii)

Q2

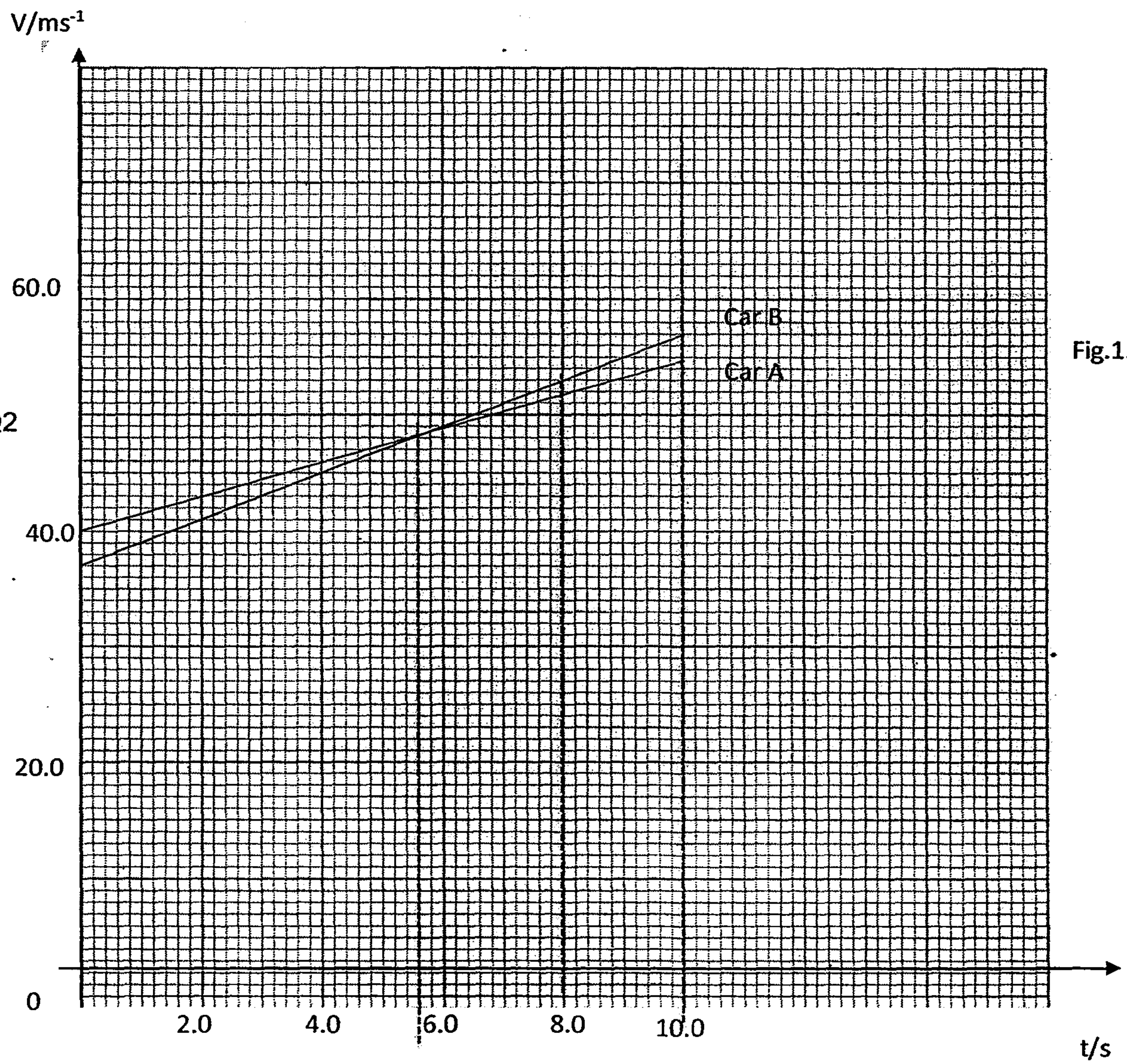


Fig.1.2

$V_A = 40 + 1.45\ (10) = 54.5$ ms^{-1}

$V_B = 37 + 2.05\ (10) = 57.5$ ms^{-1}

1(b)(iii) The area under the velocity-time graph will give the displacement of the car.

From the graph, at t = 8.0 s, the area under the graph of Car A is bigger than the area under the graph by Car B. From t = 0 to t = 5.4 s, Car A covered a larger distance. From t = 5.8 s to t = 8.0 s, Car B covered a larger distance. Comparing the 2 regions, area under the graph by car A is still more than shaded area B. Hence Car A has covered more distance than Car B at t = 8.0 s.

Or

The 2 cars' velocities are equal at t = 5.8 s. Car A is ahead of Car B. Hence for the displacement to be the same, Car B can only be together with Car A at t = 11.6 s. Hence at t = 8.0 s, car B will still be behind Car A.

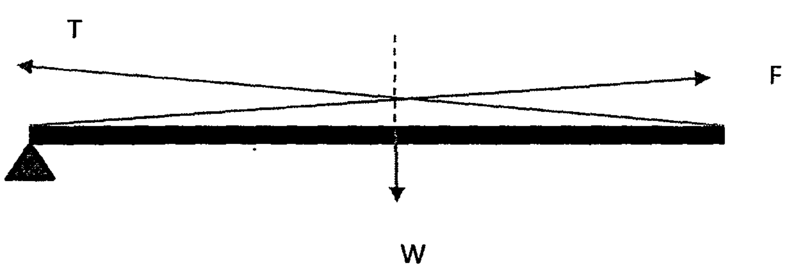
2(a)(i) Upthrust is a result of pressure difference in a fluid, due to height difference.

2(a)(ii) mg. Weight of the air inside the balloon is acting vertically downwards and is given by ρVg where V is the volume of the balloon.

The balloon will experience an upthrust in the vertically upwards direction. The magnitude of the upthrust is given by the weight of the air displaced by the balloon which is also ρVg, since the density of air is ρ and volume is also V. The 2 forces cancel one another and therefore the weighing scale gives only mg.

2(b)(i) Taking moments about the pivot, for equilibrium, the anti-clockwise moment due to T must be equal to the clockwise moment due to W. Since the perpendicular distance from the pivot to T is smaller than the perpendicular distance from W to the pivot, T must be larger than W.

2(b)(ii)

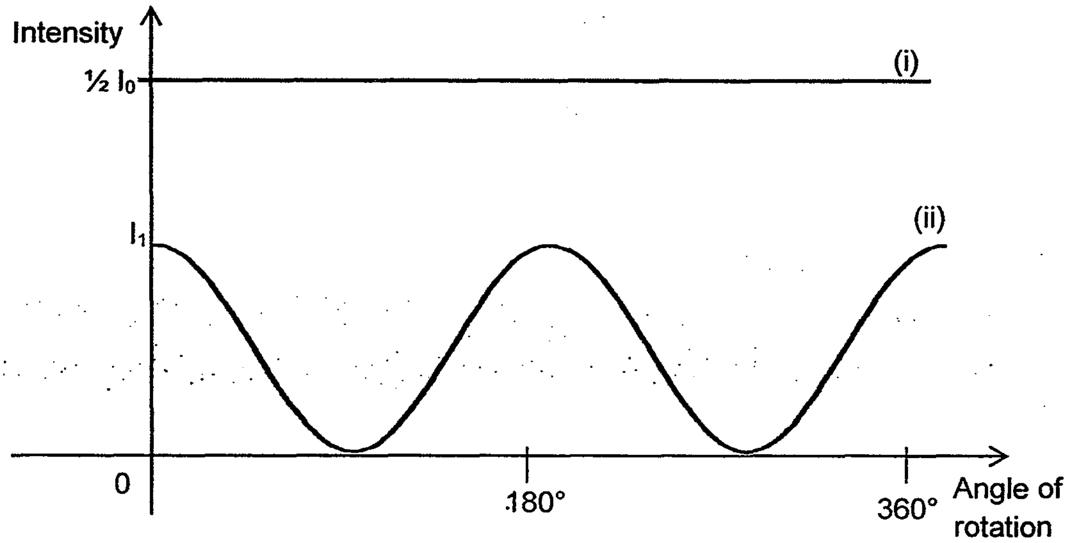


Three non-parallel forces acting on a body in equilibrium, 3 forces must pass through the same point in space. Taking moments about the end of rod, for equilibrium, the anti-clockwise moment due to W must be equal to the clockwise moment due to F. Since the perpendicular distance from the end of rod to F is smaller than the perpendicular distance from W to the end of rod, F must be larger than W.

3(a)(i) A plane polarised wave is one in which the particles' plane of vibration is fixed along a particular direction.

3(a)(ii) Sound waves are longitudinal waves. The direction of vibration of particles is parallel to the direction of travel of the wave and thus cannot be polarised. Only transverse waves can be polarised.

3(b)



3(c) Determine the highest order that can be seen on the screen,

$n_{max} \leq \frac{d}{\lambda}$

$n_{max} = 3$

1st order, wavelength = 589.59 nm, $\theta_1 = 17.15°$

1st order, wavelength = 589.99 nm, $\theta_{1'} = 17.16°$

3rd order, wavelength = 589.59 nm, $\theta_3 = 62.18°$

3rd order, wavelength = 589.99 nm, $\theta_{3'} = 62.25°$

The central maxima will be the brightest with both wavelengths combined. The highest order that can be seen on the screen is the third order. There will be a total of 13 bright fringes that will be seen including the central maxima.

4(a) From the graph, it is observed that V is inversely proportional to r and potential is defined to be zero at infinity. Values of V is negative as the charge is negative and thus work done to bring unit positive charge from infinity to the point is negative.

4(b)(i) Magnitude of electric field strength is the gradient(or slope) of the tangent or line drawn at that point.

4(b)(ii) At x = 0 cm, the electric force is the maximum (in positive x direction). From x= 0 cm to 6.0 cm, the force decreases from a maximum value to zero at x=6.0 cm. From 6.0 cm to 10 cm, the force increases from zero with direction of force is in opposite direction, i.e negative x direction.

4 (c) As the positively charge particle moves from x=0 to x =10cm, it losses electric potential energy and gain kinetic energy.

By conservation of energy,

Loss in EPE = Gain in KE

$q(570 - 230) = \frac{1}{2} mv^2$

$v^2 = 2(q/m)340 = 2(4.8\times10^7)340 = 1.8 \times 10^5 \text{ ms}^{-1}$

5(a) By Fleming's Left Hand Rule, the direction of the force on coil XY by magnet is downwards. By Newtons's 3rd Law, the force acting on the magnet by coil is upwards. The reading on balance is measured by the normal contact force acting on magnet. Once the current is switched on, the normal contact force acting on magnet is reduced, i.e weight – magnetic force on magnet. Therefore, reading on scale decreases.

5(b)(i) F = NBIL

$F = 120 \times 0.45 \times 15 \times 10^{-3} \times 2\mathrm{x}\pi \mathrm{x} 25 \times 10^{-3} = 0.127$ N

5(b)(ii) A fluctuating electric current flows through the coil.

- Since the coil is perpendicularly to a magnetic field, it experiences a magnetic force and the magnitude of force is proportional to the current.
- As the coil is attached to the speaker cone, the cone will oscillate with an amplitude that is proportional to the amplitude of current in coil.

6(a) **Existence of $\lambda_{\min}$** - To produce an x-ray photon, the accelerating electron must decelerate suddenly when it collides with the target atom.

The minimum wavelength comes about when **100% of the kinetic** energy of a electron is **loss** and converted to a single x-ray **photon of maximum** energy.

X-ray continuous spectrum/braking radiation/Bremsstrahlung – To produce an x-ray photon, the accelerating electron must decelerate suddenly when it collides with the target atom.

The kinetic energy lost by the electron can be converted into any number of photons of different energies. The wavelength of each photon is longer than $\lambda_{\min}$. Thus, a continuous spectrum is obtained.

Existence of peaks in the continuous X-ray line spectrum - A high speed electron collides and knock off an electron in an inner shell of the target atom, leaving a vacancy in the inner shell.

Electron from the outer shell (which is at a higher energy level) de-excite to fill up the vacancy in the inner shell.

When the electron de-excite, the electron loses energy. The energy loss by electron is given out as a photon with energy equal to the energy difference between the outer and inner shells. Hence the line spectrum is unique to different target materials.

(Any 2 of the above)

6(b) λ1 = 310 nm, ΔE1 = 4.01 eV

λ2 = 400 nm, ΔE2 = 3.11 eV

λ3 = 1377.8 nm, ΔE3 = 0.90 eV

n = 3 ———————— -0.09 eV

n = 2 ———————— -0.99 eV

7(a)(i) $T = Kr^{m/n}$

Rearranging, $K = T/r^{m/n}$

For values of T and r, the theory is valid if K is a constant.

Using the data from the table:

Moon	T/days	r/10^8 m	K
Metis	0.295	1.28	2.037×10^{-13}
Europa	3.55	6.71	2.042×10^{-13}
Callisto	16.7	18.8	2.048×10^{-13}

K is approximate constant with a value of 2.04×10^{-13}.

7(a)(ii) Lg (r/ m) = 8.625

Lg (T/s) = 0.248

Point (8.63, 0.25) to half the smallest square division

7(a)(iii) Gradient = [1.22-(-0.530)]/ [9.27-8.11]

= 1.75/1.16

= 1.51 = 1.5 (2 sf)

7(a)(iv) From 7(a)(i), $T= kr^{m/n}$

Linearizing: Lg T = (m/n) lg r +lg k

From fig 7.2, a straight line graph with a negative y-intercept is obtained with a gradient equals to 1.5. Hence the data fits the equation given by the theory.

7(a)(v) Based on the predicted gradient, m/n = 1.5 hence if m and n are integers, m = 3, n = 2

7(a)(vi) Using lg (r/m) = 9.27 and lg (T/days) =1.22

T = 16.6 days = 1.434×10^6s

Lg (T/s) = 6.16,

6.16 = 1.5 (9.27) +lg k

K = 1.80×10^{-8}

$1.80 \times 10^{-8} = \sqrt{(4\pi^2/GM)}$

M = 1.83×10^{27} kg

7(b)(i)1. Intensity on earth, $I = P_s/4\pi r^2$ where P_s = Power of the sun

$1400 = P_s/ 4 \pi r^2$ .....[1]

Intensity on Jupiter, $I' = P_s/ 4 \pi(5.2)r^2$ ....[2]

Eqn [2]/Eqn [1]: I = 51.8 W which is close to 50 W

7(b)(i)2. Intensity received by Juno's spacecraft = I'

$I' = P_r/A$ where P_r = Power received by the solar array.

51. 8 = $P_r/60$

P_r = 3102 W

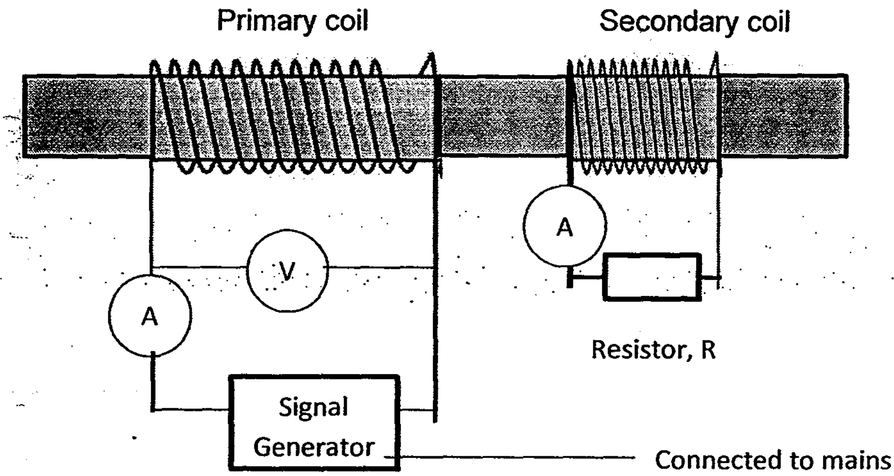
Efficiency = 500x100%/3107 = 16.1%

7(b) (ii) High speed electrons produces x-rays which may be harmful to the electronics systems in the space craft.

High speed electrons will knock out electrons in the atoms of the electronics components thereby damaging the spacecraft's system.

8

Diagram



Independent variable: frequency of the power supply, f_{in}
Dependent variable: efficiency of transformer, E
Fixed variables: the voltage of the input power, no. of coils of primary and secondary coils, Distance between the coils

Procedure:

1. Set up the rest of the apparatus as shown in the diagram above.
2. Switch on the signal generator, and set it to suitable frequency.

Measuring the variables

3. Record the input voltage V_{in} and input current I_{in} in the primary coil from the digital voltmeter and ammeter respectively.
4. Record the output I_{out} in the secondary coil from the digital ammeter.
5. Read and record the value of input frequency f_{in} from the signal generator.

Calculation of data:

6. Calculate efficiency of the transformer using $E = I_{out}^2R / V_{in} I_{in}$

Varying the independent variable:

7. Vary the input frequency to the primary coil by increasing the frequency through the signal generator by 10 Hz.

Repeating the experiment:

8. Repeat step 3 – 7 to obtain 10 sets of readings.

Analysis of data:

9. Tabulate the values of f_{in}, V_{in}, I_{in}, V_{out}, I_{out}, P_{in}, P_{out} and E.
10. The relationship of the independent variable and the dependent variable is assumed to be of the form $E = k f_{in}^n$, where k and n are constants.
11. Plot a graph of lg E vs lg f_{in}. If a straight line is obtained from the graph, determine the gradient of the line which is n. Equate lg k to the vertical-intercept. Then determine k. Hence the relationship of E and P_{in} can be deduced.

Safety Precaution:

- Ensure that the iron core and coils are well insulated to ensure that the experimenter do not get an electric shock. Alternatively wear insulated gloves when conducting the experiment.
- Do not perform the experiment for voltage more than 20 V to prevent overheating.

Additional details:

- The apparatus should also be allowed to cool down before performing each set of experiment to keep heat loss during experiment to a minimum.
- Conduct preliminary trials of the experiment to find the suitable range of input frequencies.
- Magnetic shielding should be provided to ensure that the magnetic field through the simple transformer is not affected by other sources.
- Detailed explanation of how to keep voltage of input power or distance between the coils fixed.

Paper 3

1(a)(i) Now consider a body of mass m at rest brought to velocity v over a distance s by a constant force F.

The final velocity v is given by $v^2 = u^2 + 2as$,

where a is constant acceleration given by $a = \frac{F}{m}$.

We have $v^2 = u^2 + 2\frac{F}{m}s$.

Rearranging, $\rightarrow F s = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$.

The change in Kinetic Energy of an object equals the net work done on the object.

Since the body starts from rest ($u = 0$), its final kinetic energy of body = work done on body by F = $E_k = \frac{1}{2}mv^2$.

1(a)(ii) Since the speed is constant, the change in KE is zero. Hence, by COE, the chemical energy is all used to do work against air resistance and thus no such transformation taking place.

1(b)(i) P = W/t

$36.6 \times 10^3 = W/300$, $W = 1.1 \times 10^7$ J

1(b)(ii) Not worth, since the KE $= 3.46 \times 10^5$ J even when it is moving at 31 ms^{-1} and thus will be even lower when it slows down. Hence, since the KE will be so much lower than the WD against the resistive force, a large part of the energy would still be provided by the fuel of the car.

2(a) Consider a collision that occurs when A collides with B in a straight line. By Newton's second law the change in momentum for A, $\Delta p_A = F_{BA}*\Delta t$, where F_{BA} is the force B exerts on A and Δt is the duration the force is exerted while the change in momentum for B, $\Delta p_B = F_{AB}*\Delta t$, where F_{AB} is the force A exerts on B.

By Newton's third law, $F_{BA} = - F_{AB}$ since they are an action-reaction pair.

Hence, $\Delta p_A = - \Delta p_B$.

This implies $p_{AF} - p_{AI} = - (p_{BF} - p_{BI})$, where p_{AF} is the final momentum of A, p_{AI} is the initial momentum of A, p_{BF} is the final momentum of B and p_{BI} is the initial momentum of B.

Rearranging, $p_{AI} + p_{BI} = p_{AF} + p_{BF}$. This implies the total initial momentum is the same as the total final momentum if no external force acts on this system.

2(b)(i) The total initial momentum of the system is zero. Hence the total final momentum is zero, implying that the final momentum of magnet A = -(final momentum of magnet B). If the mass of both magnets are the same, then the final velocity of magnet A = -(final velocity of magnet B).

2(b)(ii) Work was done on both magnets since an external force was applied to oppose the repulsive magnetic force between the two magnets. This was stored as potential energy between the two magnets resulting in an increase in kinetic energy when the external force was removed.

2(c) At the top of the track, Fnet = 3mg + N.
To determine the minimum velocity to keep in contact, Fnet = 3mg

Fc = $\frac{3mv_{min}^2}{r} = 3mg$

$v_{min}^2 = \sqrt{rg}$

Applying conservation of energy,
Total energy at the top of the track = Total energy at the bottom of the track

$\frac{1}{2}mv_{min}^2 + mg(2r) = \frac{1}{2}mv_B^2$

$v_B = \sqrt{5rg}$

Assumption: The track is frictionless so that no net external force acts of the system.
Applying principle of conservation of linear momentum,

$mv_0 = 3m\sqrt{5rg}$

$v_0 = 3\sqrt{5rg}$

3(a)(i) As point X is adjusted in the direction of B, the potential difference (p.d) across AX will vary. There will be a point along AB where by the p.d across AX will be equal to the e.m.f of the driven cell.
When this happens, no current will flow in the lower circuit, thereby showing a null reading on the galvanometer.

3(a)(ii) The e.m.f of the driver cell is smaller than the e.m.f of the driven cell. The p.d across the driven cell will always be greater than p.d across AX and thus the current will always flow in one direction. No null deflection will be detected.
Balance length L = 0.2 cm
Uncertainty in measurement of balance length = 0.2 cm

3(a)(iii) The balance length AX is too small to be reliable and accurate in reality. {1}
Percentage uncertainty will be large as the value of the value of the balance length approaches the value of the uncertainty of the measurement of the balance length. {1}
For example.
1 v = k 100
$2x10^{-3}$ v = k L
Balance length L = 0.2 cm
Uncertainty in measurement of balance length = 0.2 cm
Percentage uncertainty = 0.2/0.2 x100 = 100%

3(b)(i) 1.02 V

3(b)(ii) Let the balance point be X.
Resistor across balance length CX = (79/100) x 2.00 = 1.58 Ω
Total Resistance of the circuit = R_{total}
$V_{AB} = (R_{AB}/R_{total}).E$
$1.02 = (102/R_{total}).E$ ....[1]
$V_{CX} = (1.58/R_{total}).E$ .... [2]
Eqn [2]/ Eqn [1] : V_{CX} = [1.58/102] x 1.02 = 0.0158 V

4(a) Magnetic field $B = \frac{\mu_0 NI}{l} = \frac{4\pi \times 10^{-7} \times 500 \times 0.50}{0.10} = 3.14 \times 10^{-3}$ T

Magnetic flux $\Phi = BA = 3.14 \times 10^{-3} \times 1.6 \times 10^{-4} = 5.02 \times 10^{-7}$ Wb

4(b)(i) Change of $\Phi = V\Delta t = 2.0 \times 10^{-3} \times 0.20 \times 10^{-3} = 4.0 \times 10^{-7}$ Wb

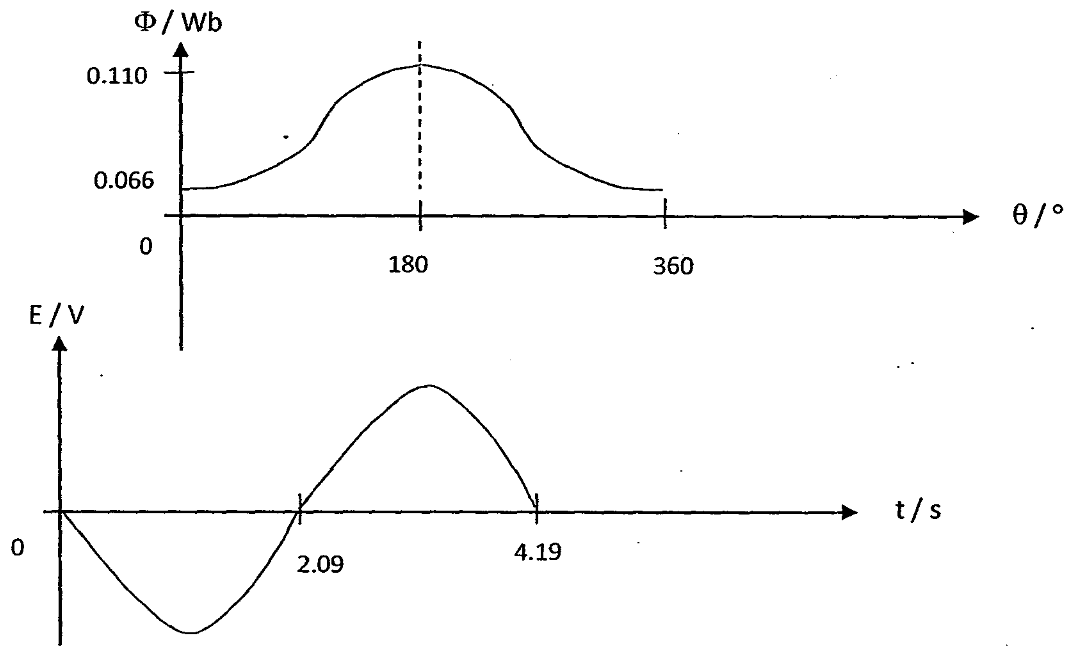
4(b)(ii) Final flux through loop = $(5.0 \times 10^{-7}) - (4.0 \times 10^{-7}) = 1.0 \times 10^{-7}$ Wb

Since cross sect A is constant, magnetic flux is proportional to current.

Since magnetic flux is reduced by 5 times, the current has decreased to 1/5 of original.

I = 0.10 A

4(c)(i)



5(a) Electrons in the n-type semiconductor diffuse across the junction to the p-type semiconductor due to higher concentration gradient. This is Vice-versa for holes from p-type to n-type)

The electrons and holes will recombine and the region will be depleted of mobile charged carriers and will leave behind immobile charged ions.

At equilibrium, the electric field set up in the depletion region will be strong enough to prevent more electrons/ holes from diffusing across from the n-type to the p-type semiconductor or p-type to n-type semiconductor respectively.

The potential difference due to this electric field within the depletion region can be thought of as a "potential energy barrier" that prevents the further migration of electrons across the junction.

5(b) (i) forward bias

5(b)(ii) When the p-type semiconductor is given a higher applied potential relative to the n-type semiconductor, the applied electric field opposes the original E-field within the depletion region. This causes the resultant electric field strength and the corresponding potential difference within the depletion region to decrease. When the applied electric field is strong enough, the potential energy barrier will be removed and a net current flows in the circuit.

OR

In forward bias connection, the width of the depletion region decreases because the electrons in the n-type semiconductor are pushed away from the negative end of the p-n junction into the depletion region while the holes are pushed away from the positive end of the p-n junction into the depletion region.

6(a) Frequency f of a body undergoing simple harmonic motion is the number of complete oscillations that the body undergoes per unit time.
Angular frequency ω of the same body is related to f by a factor of 2π i.e. $\omega = 2\pi f$.
The angle of 2π is associated with one complete cycle of oscillation

6(b) For a motion to be in simple harmonic motion, the acceleration, a must be directly proportional to displacement, x and the direction of acceleration must be in opposite direction of the displacement [1], i.e $a = -\omega^2 x$ (or $a = -kx$, k is constant) where ω is a constant(angular velocity).
Displacement of shadow, $X = R\sin\phi$

$$= R\sin\omega t \text{ where } \phi = \omega t,$$

ω is angular velocity, t is the time.

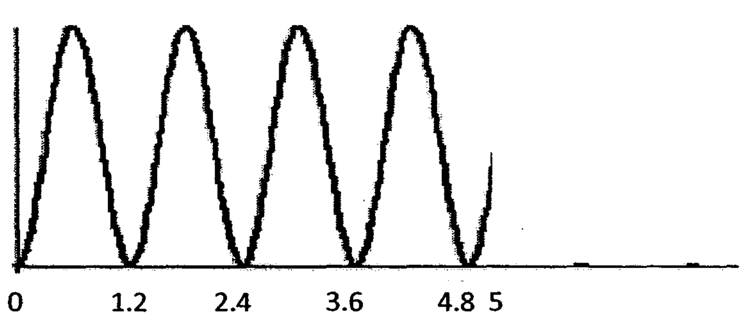
Acceleration of shadow, $a = \frac{d^2X}{dt^2} = -\omega^2 R\sin\omega t$

$$a = -\omega^2 X \text{ , since } X = R\sin\omega t$$

Therefore, the motion of shadow is simple harmonic motion.

6(c)(i) Maximum velocity is reduced since amplitude is reduced.
Max KE is reduced to one quarter of its initial maximum kinetic energy (or 4 times smaller).

6(c)(ii)



Period is 2.4s, shape
Note: student must sketch the graph up to t = 5.0s

6(d) Photoelectric effect has taken place, negatively charged electrons are emitted out from Barium, Barium acquired positive charged.

6(e) The incident photon will be absorbed by the electron if its energy is greater than work function of metal.
Since there is no accumulation of energy through absorption of multiple photons, there is no time delay in the emission of photoelectrons.

6(f) It shows the existence of discrete energy levels in hydrogen atoms. The electromagnetic radiation or photon energy occurs at certain (or discrete) frequencies, the energy levels in atoms are discrete (or quantised).
The electron in the atom de-excites from the higher energy state to a lower energy state, it will emit a photon with energy equals to the difference in the energy levels.

6(g) The electron at the metal surface require the least amount of energy to be emitted, hence it has maximum kinetic energy.
Electrons that are not directly below the surface require energy to bring it to surface, so less kinetic energy.
Hence, there is a range of kinetic energy up to a maximum value for the electrons.

6(h)(i) In a crystalline solid, the regularly arranged atoms (or the atomic spacing between the atoms is constant) acts like a diffraction grating.

6(h)(ii) The electrons behave as a wave since electron diffraction take place. Electrons are accelerated and gained kinetic energy. Only electrons of suitable kinetic energies ($E_k = \frac{p^2}{2m_e}$) have momentum and the de Broglie wavelength, i.e. $p = \frac{h}{\lambda}$ associated with this momentum is of the same order of magnitude as the atomic spacing, i.e 10^{-10} m.

7 (a) Considering 1 mole of gas of volume V_R,
$V_R = M_R / \rho$
$PV = nRT$
$P (M_R / \rho) = (1) RT$
$P = \rho RT/M_R$ (shown)

7(b) (i) $P = \rho RT/M_R$
At sea level, h = 0 m,
$P_0 = 100 \times 10^3 = (1.3) RT / M_R$ ----- (Eqn1)
At h = 8.0 km
$P_8 = 35 \times 10^3 = \rho_8 RT/ M_R$ ----- (Eqn2)
(Eqn2)/(Eqn1),
$(35 \times 10^3)/(100 \times 10^3) = \rho_8 / 1.3$
$\rho_8 = 0.455$ kg m^{-3}

7(b)(ii) $P_8 = 0.3 P_0$
$\rho_8 R (273.15 - 23) / M_R = 0.3 (1.3) R (273.15 + 20) / M_R$
$\rho_8 = 0.457$ kg m^{-3}

7(b)(iii) The specific latent heat of varporisation will decrease as the pressure at the summit of Mt Everest is smaller hence there is less work done by the water as it expands. The amount of energy required by the system to overcome intermolecular forces will remain similar to that at the sea level.

Note: The ***boiling point*** of a substance is the temperature at which the vapor ***pressure*** of the liquid equals the ***pressure*** surrounding the liquid and the liquid ***changes*** into a vapor. The ***boiling point*** of a liquid varies depending upon the surrounding environmental ***pressure***.

7(c)(i) Wave travel down the tube and gets reflected by the water.
The incident and the reflected waves, both having the same amplitude, frequency(or wavelength) and speed travelling in opposite directions superpose to form standing wave.

OR

The incident sound wave travels along the tube and is reflected by the water.
The superposition of the incident and reflected wave of same amplitude, speed and wavelength(or frequency) but travelling in opposite directions creates a standing wave in the pipe.

7(c)(ii) Air column in tube has natural frequency of vibration
When fork frequency is equal to natural frequency of vibration of air column in tube, resonance occurs; there is maximum energy transfer and maximum amplitude of vibrations occurs, leading to maximum loudness.
When fork frequency is not equal to natural frequency, no resonance occurs and loudness drop.

7(c)(iii) $\frac{\lambda}{4} = L_1 + c$ -------------(1) c is the end correction

$\frac{3\lambda}{4} = L_2 + c$ --------------(2)

$(2) - (1) \Rightarrow \frac{1}{2}\lambda = L_2 - L_1 = 32.4$ cm

$\Rightarrow \lambda = 64.8$ cm

$v = f\lambda = 512 \times 0.648 = 332$ m s^{-1}

7(c)(iv) $\frac{1}{4}\lambda = L_1 + c = 15.7 + c \Rightarrow c = \frac{1}{4} \times 64.8 - 15.7 = 0.50$ cm

Therefore, antinode is 0.50 cm above the top of the tube OR antinode is 16.2 cm above water surface.
There is a presence of end correction. The region of lowest pressure is not at the mouth of the tube but is actually a distance away from end of tube.

8(a)(i) The majority of the alpha particles pass though the gold foil undeflected.

8(a)(ii) A handful of alpha particles reflected in the opposite direction.

8(b)(i) Nuclear fusion refers to the ***combination of lighter* nuclides** to form heavier, more stable nuclei, releasing energy in the process.

OR

The building up of a larger nucleus from two nuclei of low nucleon number, with the release of energy.

8(b)(ii) Total mass of constituents = 12.099 u > 12 u. As energy will be absorbed (binding energy) when the nucleus break up, by Albert Einstein's Mass-Energy Equivalence, there will be a corresponding gain of mass ($\Delta E = \Delta mc^2$) called the mass defect. Hence, the mass of constituents will be larger.

8(b)(iii)(1) Energy released = $BE_{pdt} - BE_{rxn}$ = 90(8.5)+ 144(8.5) – 235(7.5)
=226.5 MeV = 3.62×10^{-11} J

8(b)(iii)(2) Kinetic energy of product and gamma ray photons.

8(c)(i) Random means in any sample of a radioactive material, it is not possible to predict which nucleus will decay next and thus the decay appears randomly throughout the sample.

Spontaneous means that is unaffected by environmental factors such as temperature and pressure.

8(c)(ii) The random nature would imply that there will be a lot of fluctuations in the readings of the count rate. Hence, the best-fit curve would subject to a lot of uncertainty and thus the half-lives would have a large error.

8(c)(iii) Initial count = 60 s^{-1}
Background count = 8s^{-1}
Hence, mean half-life = (65s + 70)/2 = 67.5 s

8(c)(iv) Only lead could absorb γ-ray photons and thus could prevent harmful radiation from leaking.

The lead will be hot after absorbing the γ-ray photons and thus need polystyrene to act as heat insulator.

8(d) After 3 half-lives, the count rate would be 120 s^{-1}. But the mass of iron would be reduced by to ¼ of the original mass.
But, count rate α mass of iron
Hence, count rate would be 30s^{-1}

PRELIMINARY EXAMINATIONS
Senior Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS (Section A) NO ANS **9646/03**
Paper 3 Longer 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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section A

Answer **all** questions.

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

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

For Examiner's Use	
1	
2	
3	
4	
5	
Total (40m)	

Data

speed of light in free space,	$c = 3.00 \times 10^8\ ms^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ C$
the Planck constant,	$h = 6.63 \times 10^{-34}\ Js$
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,	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall,	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2,\ v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential,	$\phi = -\frac{GM}{r}$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos\omega t \text{ and } v = \pm\omega\sqrt{(x_0{}^2 - x^2)}$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
transmission coefficient	$T \propto \exp(-2kd) \text{ where } k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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.

....

....

....

....[2]

(b) A car, of mass 720 kg, travelling along a horizontal road with a constant speed of 31 ms^{-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.

workdone = ... 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.

....

....

....

....[2]

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.

....

....

....[1]

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

....

....

....[1]

2 (c) A small block of mass $2m$ initially rests on a track at the bottom of the circular, vertical loop as shown in Fig. 2.1, which has a radius r. A bullet of mass m strikes the block horizontally with initial speed v_0 and remains embedded in the block as the block and bullet circle the loop.

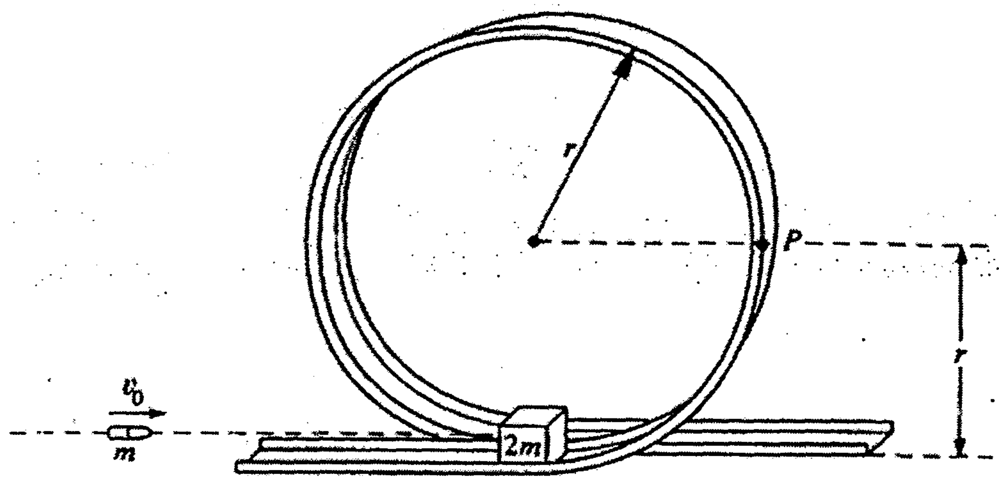


Fig. 2.1

Determine the minimum v_0 in terms of r and g, clearly stating any assumption(s) made, to ensure the block and bullet remain in contact with the track at all times.

v_0 = ... [3]

3 (a) The Fig. 3.1 below shows a simple potentiometer circuit. AB is a uniform resistance wire.

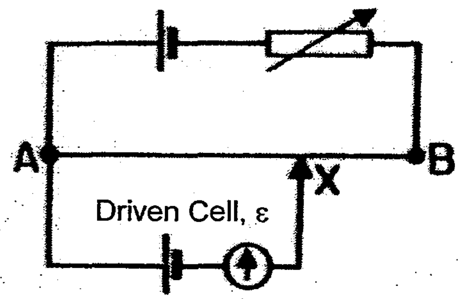


Fig. 3.1

(i) Explain why a point X may be found on the wire which gives zero galvanometer deflection.

....

....

....

....[2]

(ii) When the circuit was first setup it was impossible to find a balance point X in reality. State and explain one possible cause of this.

....

....

....[1]

(iii) When the circuit is properly setup, explain why is this circuit not suitable for the comparison of an e.m.f of a few millivolts with an e.m.f of about a volt.

....

....

....

....[2]

3 (b) The circuit in the Fig. 3.2 may be used to measure the e.m.f of a thermocouple. Both galvanometer show no deflection.

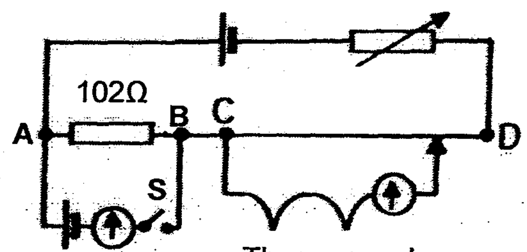


Fig. 3.2

(i) State the potential difference across the AB when the switch S is closed.

potential difference = ... V [1]

(ii) Referring to the circuit in Fig. 3.2 with switch S closed, if the resistance of uniform wire CD were 2.00 Ω, its length were 1.000 m and the balance length were 79.0 cm, what would be the e.m.f of the thermocouple?

e.m.f = ... V [3]

4 (a) An experiment is performed to investigate the magnetic field strength inside a 100 mm long solenoid of 500 turns. A small single loop of wire attached to a voltage sensor is lowered coaxially inside the solenoid, as shown in the Fig. 4.1, until it is at the centre of the solenoid.

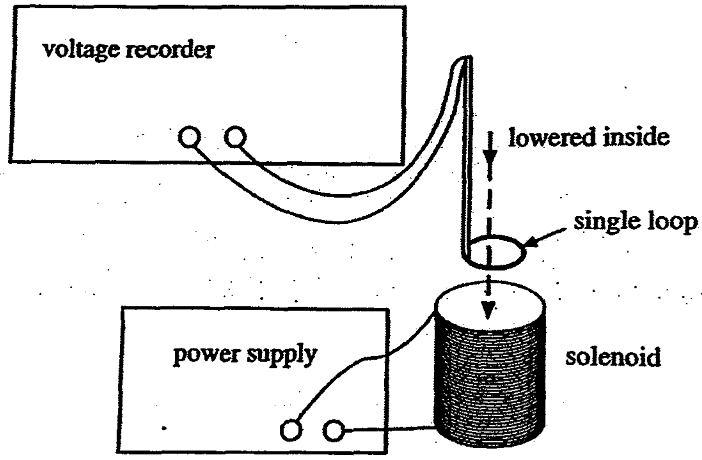


Fig. 4.1

The solenoid is supplied with a steady current of 0.50 A.
The magnetic flux density, B at a point on the axis well inside a long solenoid is given by

$$B = \frac{\mu_o N I}{l}$$

where N is the number of turns on the solenoid, l is the length of solenoid, μ_o is permeability of free space and I is the current flowing in the solenoid.

The single loop of wire is positioned at the centre of the solenoid so that it is at right angles to the magnetic field. If the loop has an area of 160 mm^2, calculate the magnetic flux through the loop.

magnetic flux = ... Wb [1]

4 (b) The current through the solenoid is decreased to a lower value at a steady rate and the graph as shown in Fig. 4.2 is obtained using data from the voltage sensor.

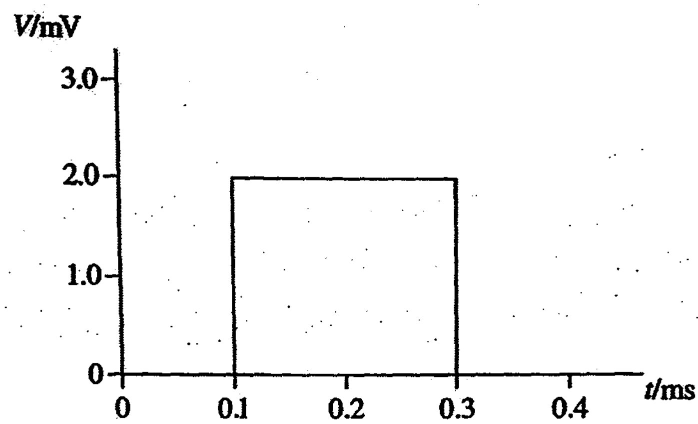


Fig. 4.2

(i) Calculate the change of flux through the loop.

change in magnetic flux = ... Wb [1]

(ii) Determine the new value of the current flowing in the solenoid.

current = ... A [1]

4 (c) Fig. 4.3 shows a coil of copper wire made up of two semicircles joined by two straight sections of wire. The total resistance of the coil is 0.025 Ω. The coil is lying flat on a horizontal surface. Starting from the orientation in Fig. 4.3, the smaller semicircle of radius 0.20 m rotates at an angular frequency 1.5 rads^{-1} about the dashed line. The angle θ is the angle of rotation measured from the horizontal position as shown in Fig. 4.4. A uniform magnetic field of magnitude 0.35 T is directed upwards, perpendicular to the horizontal surface.

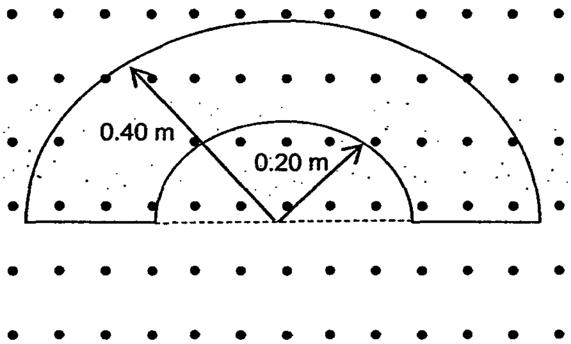


Fig. 4.3: Top View

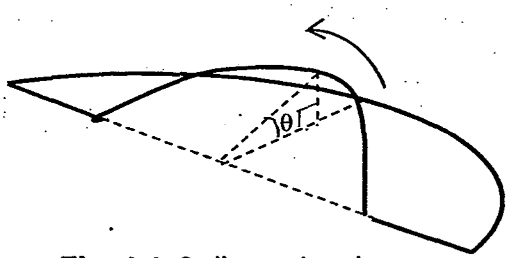
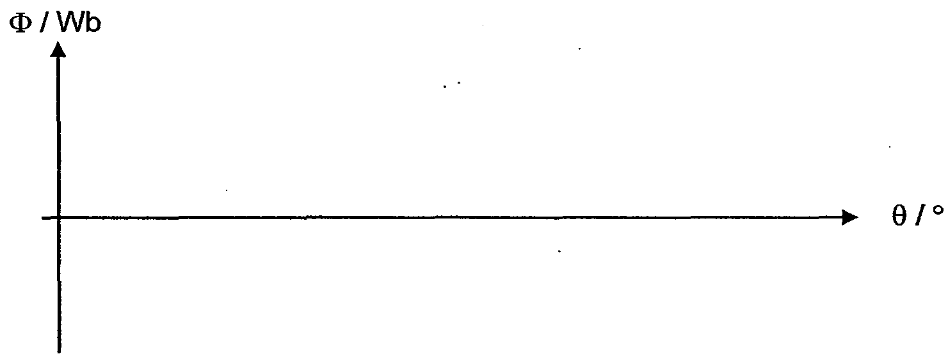
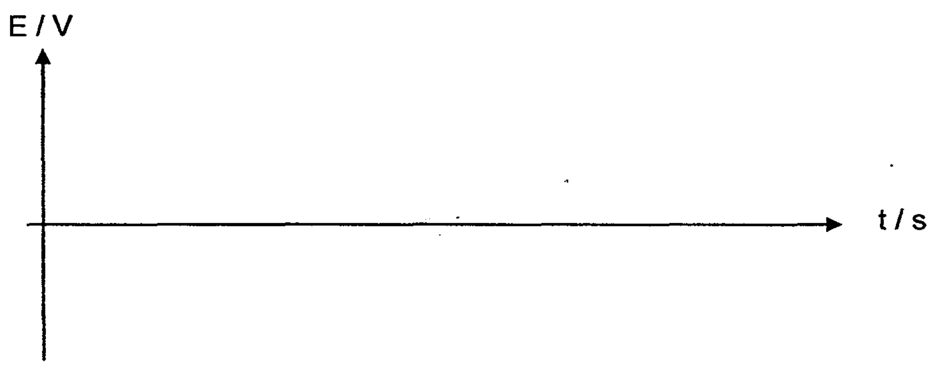


Fig. 4.4: 3-dimensional

(i) On the axes below, sketch the variation of the magnetic flux, Φ through the coil with θ, for one full cycle. Indicate all the important values. [2]



(ii) Hence, sketch on the axes below, the variation of the induced emf, E in the coil with time, t for one complete cycle. [2]



5 **(a)** Describe the origin of the depletion region at the pn junction.

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....[4]

(b) A pn junction is placed in the circuit as shown in Fig. 5.1.

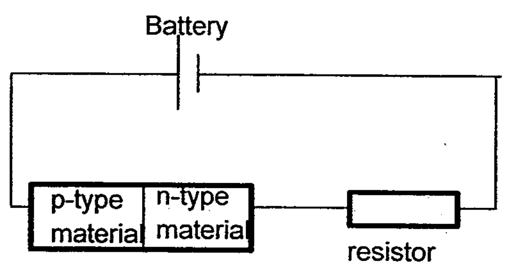

Fig. 5.1

(i) Referring to the circuit in Fig. 5.1, identify if the pn junction is forward bias or reversed bias.

.... bias [1]

(ii) Describe the origin of the bias connection that you have identified in **(b)(i).**

....

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....

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....

....

....[3]

END OF Section A

PRELIMINARY EXAMINATIONS
Senior Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS (Section B)
Paper 3 Longer Structured Questions

9646/03
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 an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

For Examiner's Use	
6	
7	
8	
Total (40m)	

Section B

Answer any **two** questions.

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

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

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ C$
the Planck constant,	$h = 6.63 \times 10^{-34}\ Js$
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,	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant,	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall,	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2,\ v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential,	$\phi = -\frac{GM}{r}$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos\omega t$ and $v = \pm\omega\sqrt{(x_0{}^2 - x^2)}$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
transmission coefficient	$T \propto \exp(-2kd)$ where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

Section B

Answer **two** questions from this Section in the spaces provided.

6 (a) Distinguish between *frequency* and *angular frequency* for a body undergoing simple harmonic motion.

....

....

....[1]

(b) A rod is mounted on a rotating turntable, rotating anticlockwise with a constant angular velocity. The setup is illuminated from the left by a light source. The rod forms a shadow X on the screen at the right hand side, as shown in Fig. 6.1. Explain clearly, with suitable workings, why the motion of the shadow is simple harmonic.

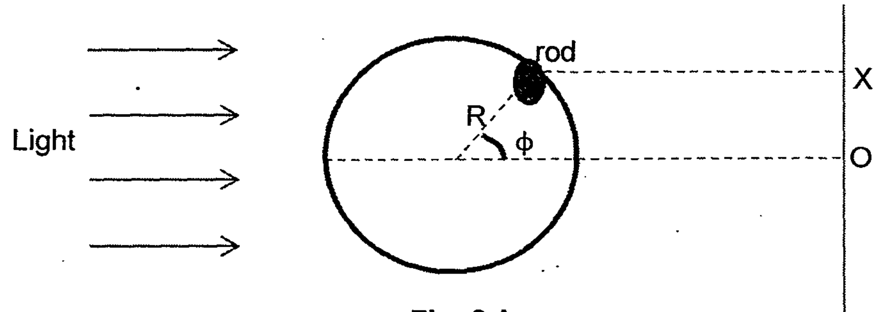

Fig. 6.1

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....[3]

6 (c) Fig. 6.2 shows a simple pendulum consisting of a steel sphere suspended by a light string from a rigid support. The sphere is displaced 50 mm from its vertical equilibrium positon and released at $t = 0$.

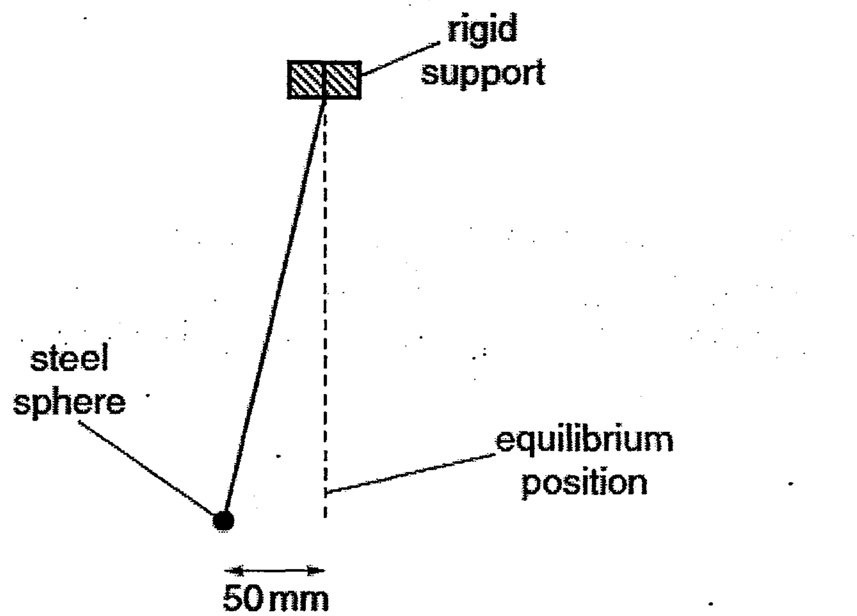

Fig. 6.2

Fig. 6.3 shows the graph of displacement x of the sphere against t.

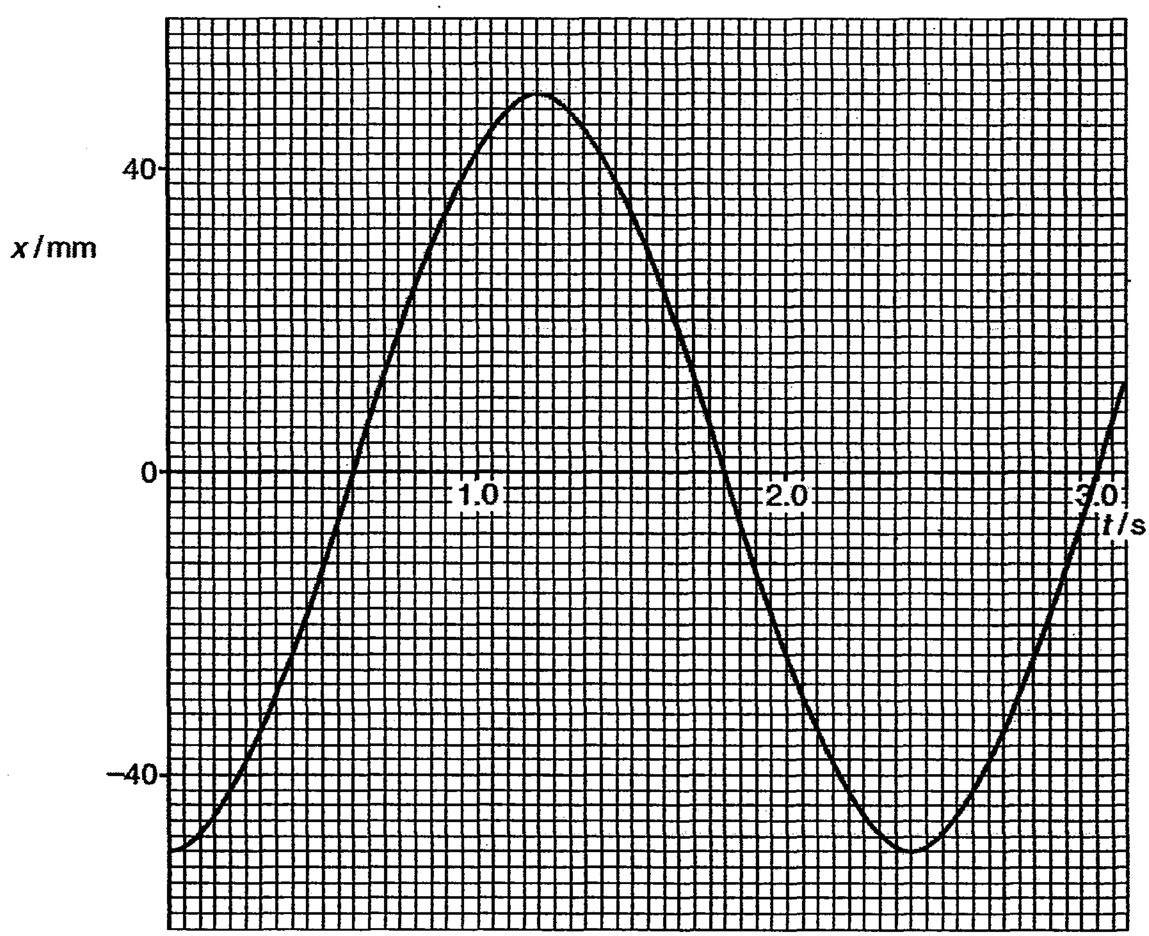

Fig. 6.3

6 (c) The sphere is now released from rest with a displacement x= 25 mm.

(i) State with a reason, the change if any in the maximum kinetic energy of the sphere.

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....

....[2]

(ii) Sketch the kinetic energy of sphere vs time for $0 < t < 5.0$ s on Fig. 6.4. [1]

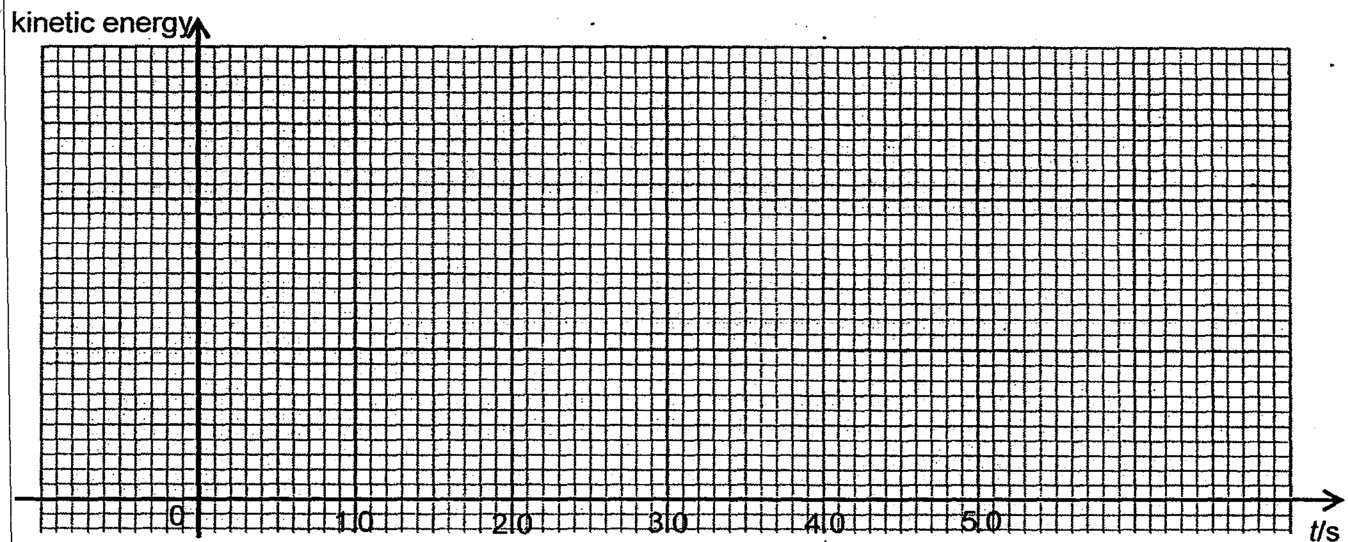

Fig. 6.4

(d) 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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....

....

....[2]

(e) 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.

....

....

....

....[2]

6 (f) Fig. 6.5 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.

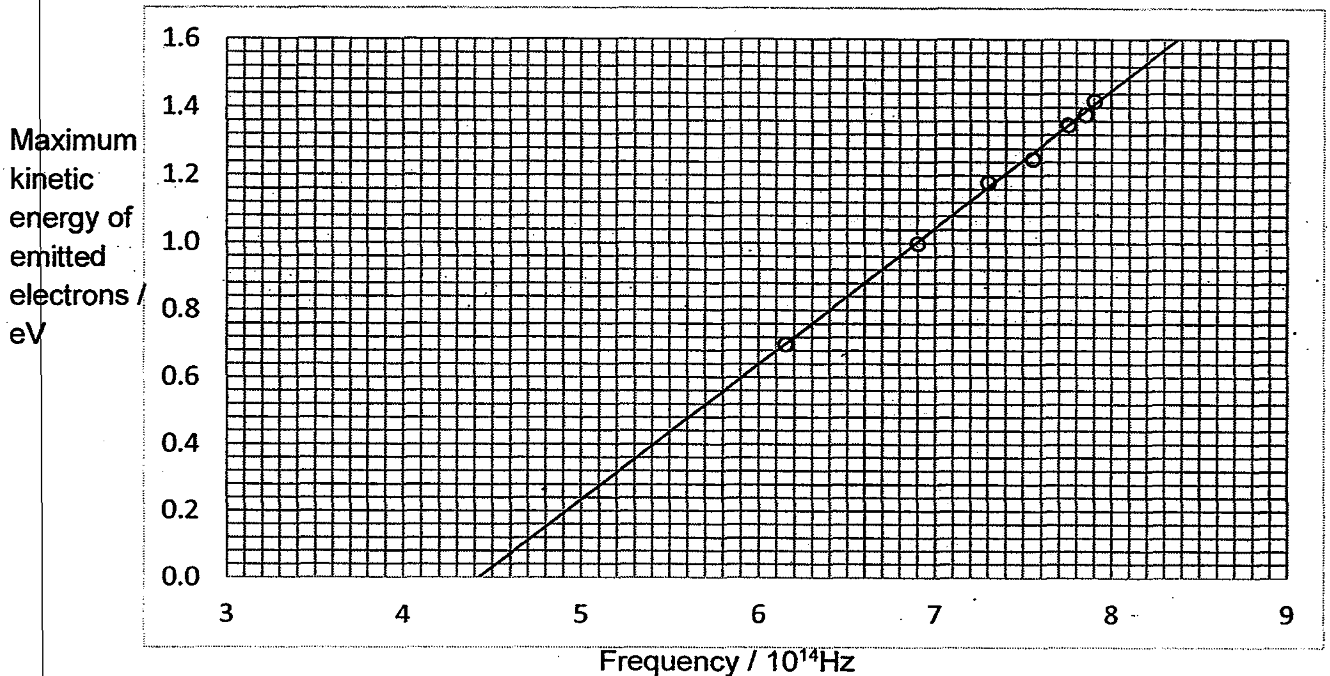

Fig. 6.5

The frequencies of light from the lamp, shown by the small circles on the Fig. 6.5 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]

6 **(g)** 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.

....

....

....

....[2]

(h) 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.

....

....[1]

(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.

....

....

....

....[3]

7 **(a)** The equation of state of an ideal gas is $PV = nRT$. Data about gases are often given in terms of density ρ rather than volume V. Show that the equation of state for a gas can be written as $P = \rho RT/M_R$ where M_R is the mass of one mole of gas.

[2]

(b) One simple model of the atmosphere assumes that air behaves as an ideal gas at a constant temperature. Using this model the pressure P of the atmosphere at a temperature of 20 °C varies with height h above the Earth's sea level as shown in Fig. 7.1.

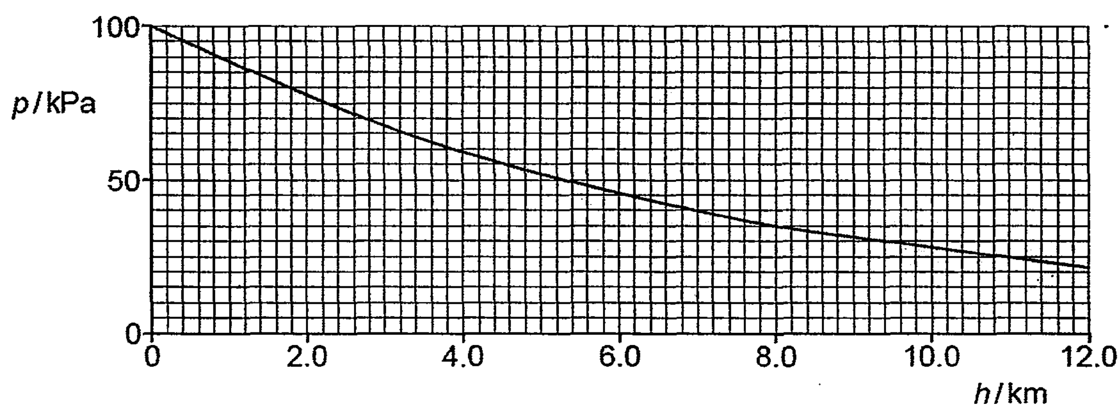

Fig. 7.1

(i) The ideal gas equation in **(a)** shows that, at constant temperature, pressure P is proportional to density ρ. Use data from Fig. 7.1 to find the density of the atmosphere at a height of 8.0 km.
Density ρ of air at sea level is 1.3 kg m^{-3}.

ρ = ... kg m^{-3} [3]

7 (b) (ii) In the real atmosphere the density, pressure and temperature all decrease with height. At the summit of Mt. Everest, 8.0 km above sea level, the pressure is only 0.30 of that at sea level.

Take the temperature at the summit to be –23 °C and at sea level to be 20 °C.

Calculate, using the ideal gas equation, the density of the air at the summit.

density = ... kg m^{-3} [3]

(iii) Using the kinetic theory, explain any changes to specific latent heat of vaporisation of water at the summit of Mt Everest as compare to at the sea level.

....

....

....

....[2]

7 (c) 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. 7.2 and Fig. 7.3.

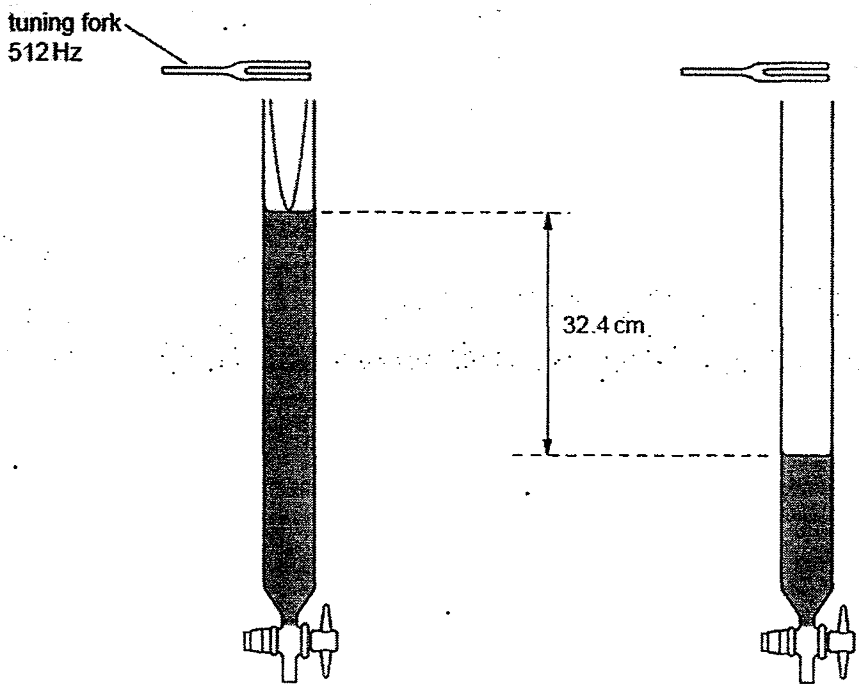

Fig. 7.2 **Fig. 7.3**

A loud sound is first heard when the water level is as shown in Fig. 7.2, and then again when the water level is as shown in Fig. 7.3. Fig. 7.2 illustrates a stationary wave produced in the tube.

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

....

....

....

....[2]

(ii) Explain, by reference to resonance, why the loudness of the sound changes as the water level changes.

....

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....[3]

7 (c) (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. 7.2 is 15.7 cm. Suggest and explain where the antinode of the stationary wave produced in the tube in Fig. 7.2 is likely to be found.

....

....

....

....[2]

8 (a) Classic experiments on alpha-particle scattering were performed by Rutherford

State the experimental observation obtained from such experiments which suggested that

(i) the nucleus is small

....

....[1]

(ii) the nucleus is massive and charged.

....

....[1]

(b) **(i)** Define Nuclear Fusion.

....

....[1]

(ii) By definition, the mass of the $^{12}_{6}C$ atom is 12u exactly. Explain why the sum of the masses of the constituents of the $^{12}_{6}C$ atom is not 12 u exactly. The masses of the electron, proton and neutron are 0.00055 u, 1.00728 u and 1.00867 u respectively.

....

....

....

....[2]

8 **(b)** **(iii)** Uranium nuclei when bombarded by neutrons may undergo nuclear

reactions. One such reaction is

$$^{235}_{92}U+^{1}_{0}n\rightarrow^{144}_{56}Ba+^{90}_{36}Kr+2^{1}_{0}n$$

1. Determine the energy change in this reaction. The binding energy per nucleon of $^{235}_{92}U$, $^{144}_{56}Ba$ and $^{90}_{36}Kr$ are 7.5 MeV, 8.5 MeV and 8.5 MeV respectively.

energy change = ... J [1]

2. Suggest two forms of energy into which the energy calculated above is transformed during a reaction of this type.

....

....

....[2]

8 (c) An experiment is carried out in which the count rate is measured at a fixed distance from a sample of a certain radioactive material. The decay process is random and spontaneous. Fig. 8.1 shows the variation of count rate with time t that was obtained.

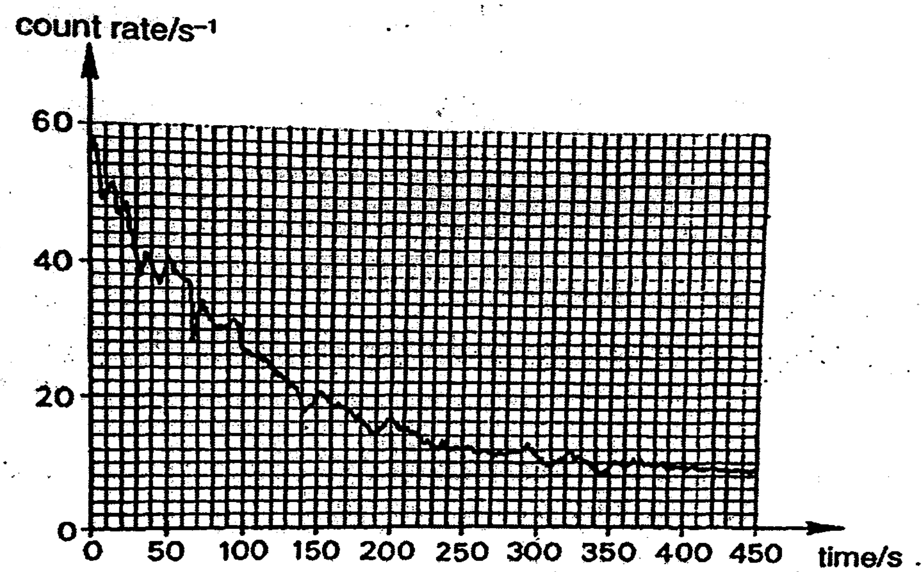

Fig. 8.1

(i) Define the terms *random* and *spontaneous*.

....

....

....

....[2]

(ii) Explain why the random nature of radioactive decay makes it difficult to measure the value of half-life to a high degree of accuracy.

....

....

....

....[2]

8 (c) (iii) Use Fig. 8.1 to estimate the half life of the material

half-life = ... s [2]

(iv) The material which may emit γ-rays is to be transported in a sealed wooden box, which is a lead container surrounded by expanded-polystyrene as shown in Fig. 8.2.

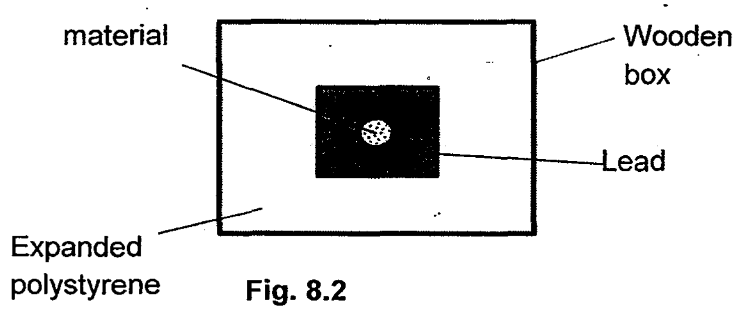

Fig. 8.2

Suggest why, on health grounds, the source is placed in a lead container surrounded by expanded polystyrene.

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....

....[2]

8 (d) Radioactive iron has a half-life of 46 days. It is used medically in the diagnosis of blood disorders. Measurements are complicated by the fact that iron is excreted, i.e. removed, from the body at a rate such that 69 days after administering a dose, half of the atoms in the dose have been excreted.

If the count rate from a blood sample is 960 counts per minute, calculate the count rate from a similar blood sample taken 138 days later.

count rate = ... min^{-1} [4]

END OF PAPER