Section I

Total marks (75)
Attempt Questions 1–15
Allow about 30 minutes for this part
Use the Multiple Choice Answer Sheet provided

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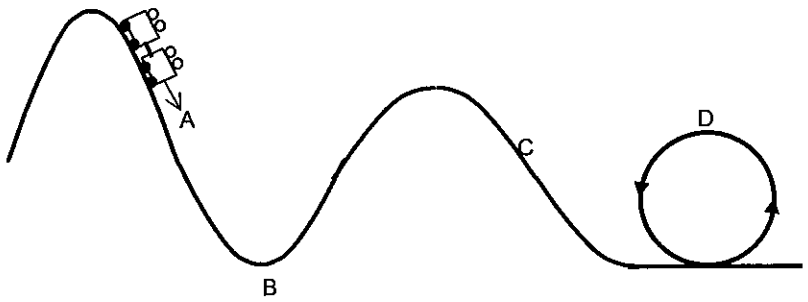
1 At which point of the roller coaster ride would the passengers experience *g* forces similar to those experienced by an astronaut during the first stage of launch?



(A) A
(B) B
(C) C
(D) D

2 Two asteroids in deep space have mass M kg and are separated by r km. The gravitational potential energy of the asteroid pair is E joules.

If the separation between the asteroids were to be decreased to $\frac{r}{2}$ km, which of the following would best describe the resulting gravitational potential energy?

(A) There is no change in gravitational potential energy of the system
(B) There is an increase of the gravitational potential energy of E joules
(C) There is a decrease of the gravitational potential energy of E joules
(D) There is an overall change of the gravitational potential energy of $2E$ joules

3 A space shuttle mission has just reached its equatorial orbit, 380 km above the surface of Earth, when a huge solar flare sends a strong burst of solar wind directly towards the shuttle. Which of the following correctly describes the most likely effect this outburst of solar wind will have for the astronauts in the shuttle?

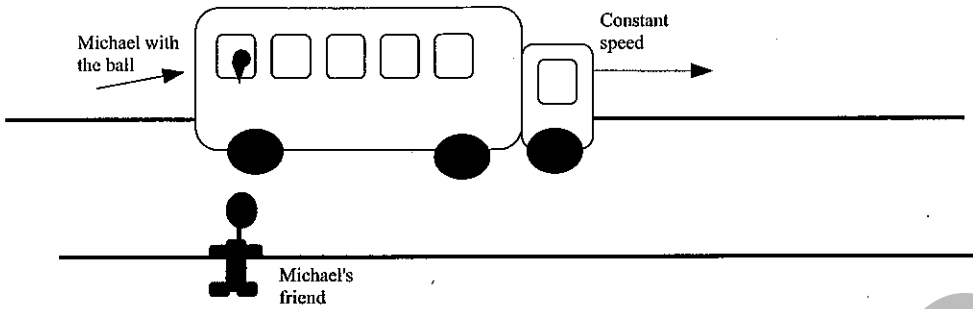
(A) They will abort the mission and immediately return to the Earth's surface
(B) They will need to have special radiation suits for protection while they continue their mission
(C) They will immediately lose communication with the Earth and remain isolated for some time, but will continue with their mission
(D) The astronauts may have some communication interruptions but will likely experience few other problems as they are inside the Van Allen belts

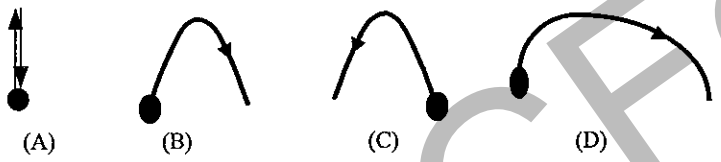
4 Michelson and Morley attempted to measure the relative velocity of the Earth through the ether. They rated their experiment a failure because the expected outcome did not occur.

(A) It was thought the experiment had failed because the atmosphere interfered with the passage of the light, probably causing refraction of the light
(B) It was thought the experiment had failed because the equipment was not adequate to produce the expected outcome
(C) The experiment did not fail but actually demonstrated that the ether did not exist
(D) The experiment was performed only once and was thought to fail for undetermined reasons; the experiment was then abandoned

5 Michael, a keen Physics student, showed his friend that throwing a ball up in the air on a stationary bus results in the ball moving in the path shown below.

If Michael's friend stands in the position shown below as the bus moves past him at a constant speed, which of the alternatives best represents the path the ball follows as viewed by Michael's friend?





6 Two long parallel wires are carrying equal currents of size I in the same direction. When the separation of the wires is d m, a force of attraction of magnitude F Nm^{-1} exists between the two wires. If the size of both the currents and the separation of the wires are doubled, which of the following would be the new force?

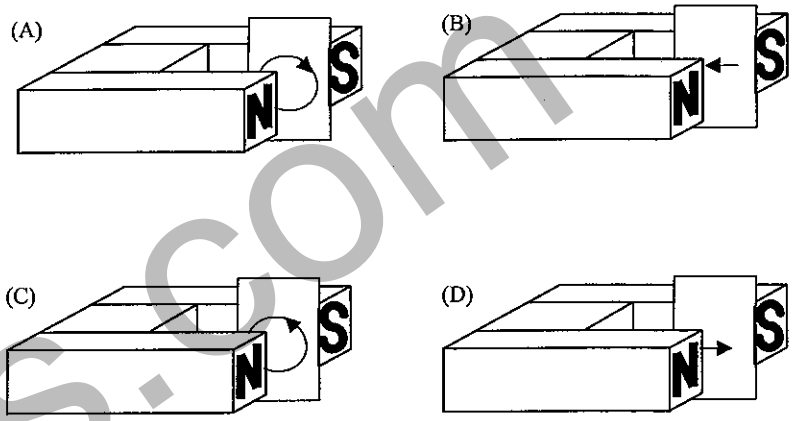
(A) $\frac{F}{2}$

(B) 4F

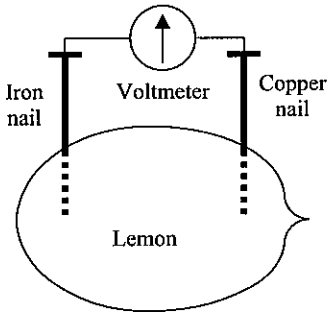
(C) F

(D) 2F

7 An aluminium sheet was dropped and fell down through a magnetic field. In which diagram is the direction of the induced current shown by the arrowhead.



8 During an experiment, a copper nail and an iron nail are both inserted into a lemon without touching one another. A voltmeter is connected across the nails and reads 0.52 volts.



Which of the following correctly describes what this experiment indicates?

(A) In this experiment chemical energy is being converted into electrical energy which is driving a DC voltmeter

(B) This experiment shows the principle of an early voltaic cell producing an AC potential difference

(C) This experiment shows the principle of an early electromechanical generator which functioned without a split ring commutator

(D) In this experiment the iron nail is at a higher potential than the copper nail so the conventional current flows from iron to copper outside the lemon

9 Superconductivity has many applications, such as in the Maglev train. Which of the following is the biggest draw back of the use of superconductors in the train, making the system impractical?

(A) The superconductors are too heavy for the system to work efficiently

(B) Superconductors require very low temperatures to work efficiently

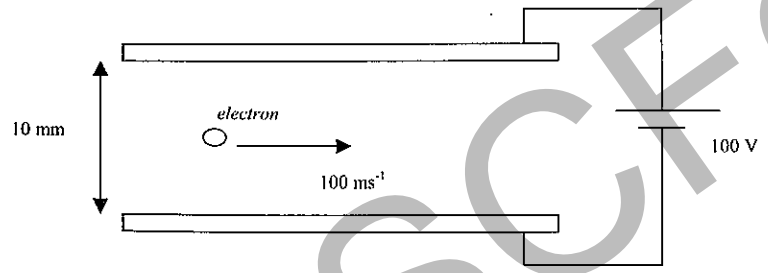
(C) Superconductors are very expensive

(D) The lift required for the train to run cannot be produced by the superconductor

10 AC Induction motors are commonly used in small power tools used around the home. Which of the following alternatives lists one advantage and one disadvantage, of the AC induction motor?

	Advantage	Disadvantage
(A)	low maintenance on parts	low power
(B)	high power	high maintenance on parts
(C)	low maintenance on parts	high power
(D)	high maintenance on parts	low power

11 An electron is fired at 100 ms^{-1} between two parallel charged plates, as shown.



The plates are separated by 10 mm, and have an applied potential of 100V. A magnetic field exists such that the electron is undeflected as it travels between the plates.

Which of the following is the correct magnetic flux density?

(A) 0.1T into the page

(B) 0.1T out of the page

(C) 100T into the page

(D) 100T out of the page

12 Which of the following is **NOT** a reason why silicon became the preferred material for manufacture of semiconductors?

(A) It has four electrons in the outer shell

(B) It forms an oxide layer when heated

(C) It retains its semiconducting properties better than other materials at higher temperatures

(D) It is very abundant

13 A certain photon is found to have an energy of 4.4×10^{-19} J. Which of the following is the wavelength and frequency of this light?

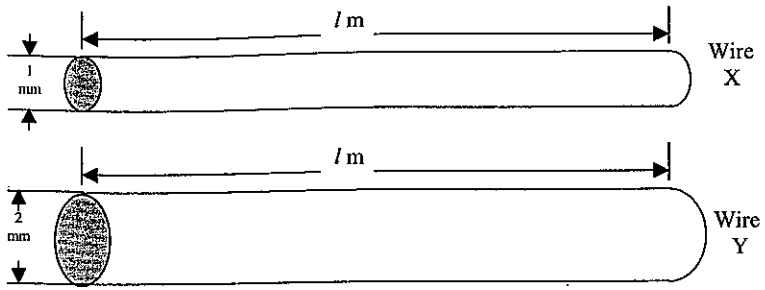
	Wavelength (nm)	Frequency (MHz)
(A)	1.5×10^{-8}	2.0×10^{17}
(B)	4.5×10^{-7}	6.6×10^{-14}
(C)	1.5×10^{-15}	2.0×10^{23}
(D)	450	6.6×10^{8}

14 A particular transformer has 1000 loops in the Primary coil and a supply voltage of 240V AC. The transformer produces a 12.0V AC. output at the secondary coil, which is supplying the power to run an electric motor that draws a current of 4.0A. If this is an ideal transformer, which of the following is true?

	Number of loops in Secondary	Current flowing into Primary coil
(A)	50	0.20 A
(B)	50	0.50 A
(C)	20000	0.20 A
(D)	20000	0.50 A

15 Two wires, X and Y, carry the equal electric currents, are the same length (l metres), are made of the same material and are at the same temperature.

v_X and v_Y are the drift velocities in X and Y respectively



Which of the following alternatives best describes the relationship between the drift velocity in the two wires?

(A) $v_X = 4v_Y$

(B) $v_X = 2v_Y$

(C) $v_X = \frac{1}{2}v_Y$

(D) $v_X = \frac{1}{4}v_Y$

End of Section I Part A

Section I

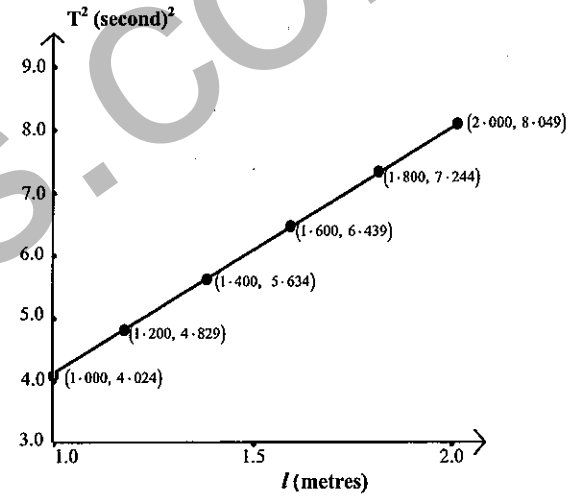
Part B

Total marks (60)
Attempt Questions 16–28
Allow about 1 hour and 45 minutes for this part

Show all relevant working in questions involving calculations.

Question 16 (8 marks) **Marks**

(a)



The graph shows a plot of six readings taken from a simple pendulum experiment, the square of the period of the pendulum (T^2) being plotted against the length of the pendulum (l (metres)).

Based on your knowledge, explain fully what is shown by the information above. **3**

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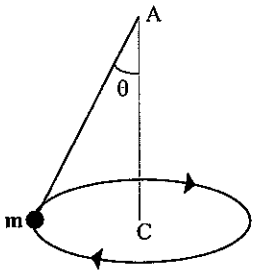
Question 16 continued on page 10

Question 16 (continued) **Marks**

(b)



The diagram shows a conical pendulum with a mass **m** moving with constant speed in a circle of centre C. The angle to the vertical (as shown) is θ.

(i) On the diagram above mark in the forces acting on **m**. **1**

(ii) Using the forces from (i), derive an expression for the force (P) which is keeping the body moving in the circle. **2**

(c) An astronaut in orbit around the Earth, decides to make a simple pendulum in his space craft. He attaches one end of a piece of string to the ceiling and the other end to a mass held 10cm above the floor. He now displaces the mass sideways by 20cm and releases it. Describe what happens to the mass and explain why. **2**

End of Question 16

Question 17 (3 marks) **Marks**

Einstein used thought experiments to help explain his theory of relativity. Describe a thought experiment which could be used to explain the relativity of simultaneity. **3**

Question 18 (3 marks)

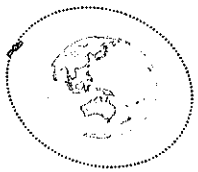
(a) Communications between interplanetary probes and Earth stations are made difficult due to a number of factors. Describe TWO such factors. **2**

(b) Microwaves are preferred over radio waves for communications between Earth and spacecraft. Explain ONE reason for this preference. **1**

Question 19 (6 marks) **Marks**

A satellite is orbiting the Earth in a more or less circular path, completing each orbit in 90 minutes.

Not to scale



(a) Describe fully the nett force that is acting on the satellite. **2**

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(b) Using the known data for the Earth, explain how the average distance of the satellite above the Earth's surface can be determined, and calculate the value. (Radius of the Earth $R_E = 6.33 \times 10^6$ m) **4**

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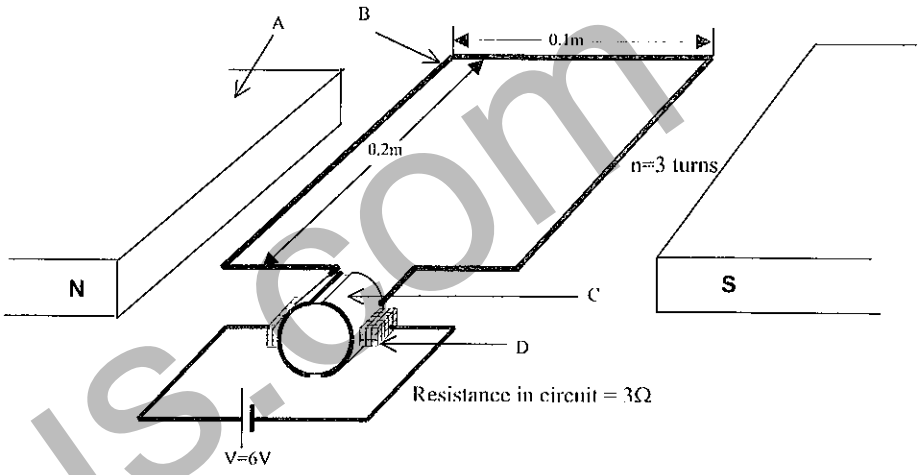
Question 20 (6 marks) **Marks**

(a) Below is a sketch of a simple DC motor



Name each of the labelled parts. **2**

A: .....

B: .....

C: .....

D: .....

(b) Outline the importance of part C in keeping a DC motor working. **1**

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(c) The magnetic flux density produced in the motor above is 0.5T. When the coil is positioned within the motor so that half the maximum torque is produced, calculate the numerical value of the torque. **1**

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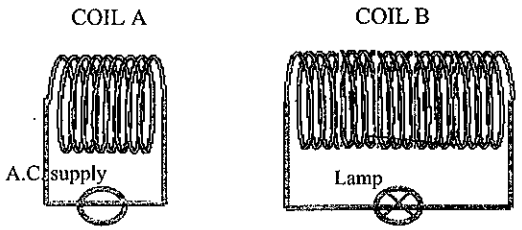
Question 21 (4 marks) **Marks**

(a) Two coils of wire are situated near to each other as shown. Coil A is connected in series with a source of alternating current, while coil B has a small lamp in a series connection **2**

Explain why the lamp connected to coil B glows when circuit A is switched on.



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(b) A piece of soft iron in the shape of a rod is passed through both coil A and coil B. The following observations were made during the experiment: **1**

(i) the rod became warmer

(ii) the lamp glow became brighter

Describe why the rod becomes warmer.

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(c) Account for the change observed in the brightness of the lamp. **1**

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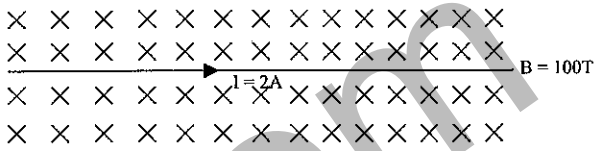
Question 22 (7 marks) **Marks**

(a) A wire carrying a current of 2A is place in an external magnetic field of 100T. The wire is perpendicular to the magnetic field. **1**



(i) If the wire experiences a force of 4N, calculate the length of the wire. **1**

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(ii) In which direction does the wire move?

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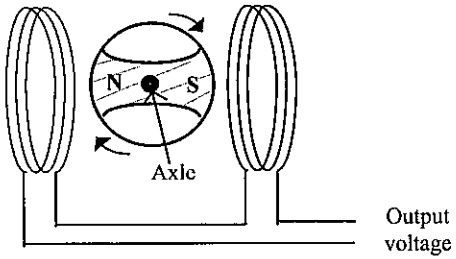
(b)



In one design of a generator a powerful magnet rotates on an axle between two fixed coils connected in series. **2**

(i) Is the output voltage AC or DC? Why?

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(ii) State ONE advantage that this design has over a conventional design. **1**

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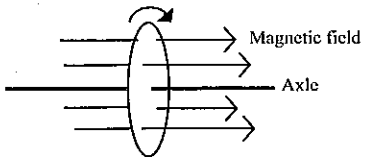
Question 22 continues on page 16

Question 22 (continued) **Marks**

(c)



A thin solid metal disk is rotating on a horizontal axle. Parallel to the axle is a strong magnetic field.

(i) Determine the direction of the emf induced. **1**

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(ii) Give an example of where eddy currents have been used in industry. **1**

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Question 23 (3 marks)

Describe a technique you investigated to demonstrate the principle of an AC induction motor. **3**

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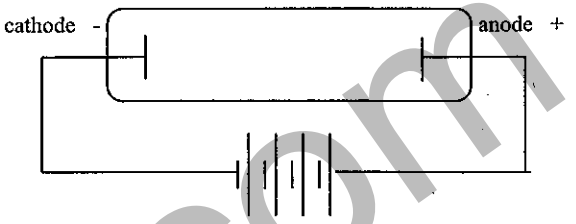
Question 24 (4 marks) **Marks**

Sir William Crookes was trying to determine whether rays are emitted from the cathode or anode when produced in an experimental setup as shown below.



(a) Briefly describe the technique he used it show that the rays originated from the cathode. **2**

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(b) Outline how the cathode ray in a television set is manipulated in order to produce the picture that is seen when viewed. **2**

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Question 25 (3 marks) **Marks**

(a) What is meant by a "black body"? **1**

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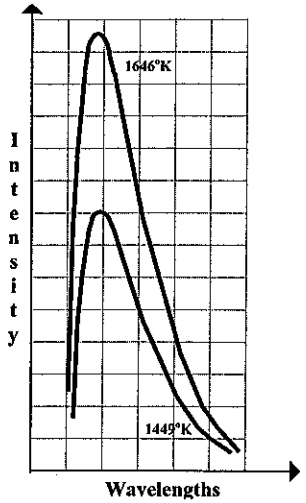
(b)



The above diagram shows the shape of the curve for the intensity of thermal radiation from a black body plotted against the distribution of wavelengths at two different temperatures. State the contribution that Planck made in his efforts to find a general formula for these curves. **2**

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Question 26 (6 marks) **Marks**

Solid state components have changed the nature of electrical devices. Discuss why this advance occurred and how it has affected society. **6**

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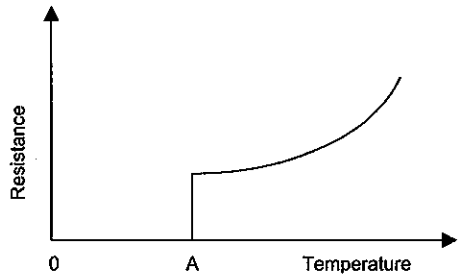
Question 27 (3 marks)

(a) Give the name for the temperature marked as "A" on the graph below, and explain its physical significance. **2**



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Question 27 continued on page 20

Question 27 (continued) **Marks**

(b) At room temperature a metallic conductor exhibits a small resistance to the flow of electric current, which results in an increase in temperature of the conductor. Discuss the reason for this increase in temperature. **1**

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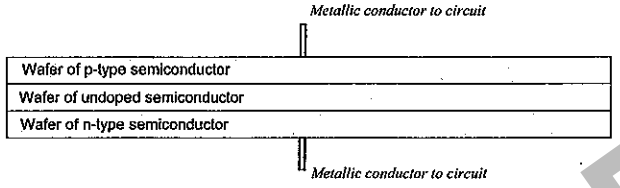
Question 28 (4 marks)

The diagram below represents a solar cell consisting of an extremely thin wafer of p-type semiconductor fused to an undoped wafer, and a third thin wafer of n-type semiconductor. Metallic conductors running across the p and n-type wafers, conducts charge from the solar cell. **4**

When an electron is released by a photon, a current will begin to flow in a circuit attached to the solar cell.



Describe how the photoelectrons released by light falling on the solar cell will flow as a current through the wafers of semiconductor, and explain which of the wafers will be acting as the negative terminal of the solar cell, to supply current to an attached circuit.

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End of Section I Part B

Section II – Options

Total marks (25)
Attempt ONE question from Questions 29–33
Allow about 45 minutes for this section

Answer the question in a SEPARATE writing booklet.

Show all relevant working in questions involving calculations.

Question 32 – From Quanta to Quarks (25 marks) **Marks**

(a) (i) Define the symbols used in Bohr's equation. **1**

(ii) Explain what happens to the energy levels of the hydrogen atom as the quantum numbers of those levels increase. **2**

(b) (i) Describe de Broglie's proposal concerning "matter" waves? **1**

(ii) Describe how Davisson and Germer confirmed de Broglie's theory of matter waves. State any limitation(s) of this confirmation. **3**

(c) Calculate the energy released by the following nuclear fission equation: **4**

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{88}_{38}Sr + {}^{136}_{54}Xe + 12\ {}^{1}_{0}n$$

The atomic mass of $^{88}_{38}Sr$ = 87·9056250 u

The atomic mass of $^{136}_{54}Xe$ = 135·907220 u

The atomic mass of $^{235}_{92}U$ = 235·043925 u

Give your answer in SI units.

(d) Discuss the limitations of the Bohr model of the hydrogen atom. **6**

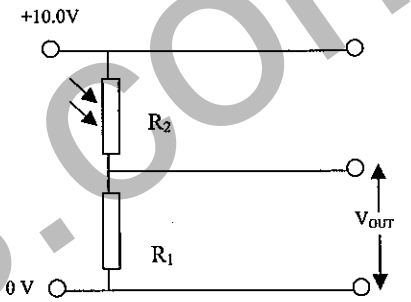
(e) Discuss the optical microscope and the electron microscope in respect to their resolving powers, their applications and the impact of their development on mankind. **8**

End of Question 32

Question 33 – Age of Silicon (25 marks) **Marks**

(a) A light emitting diode (LED) is an example of an output transducer. Name ONE other output transducer. **1**

(b) (i) A light-dependent resistor (R_2) is shown below. Outline how the output voltage would vary as the amount of light falling on the light-dependent resistor increased. R_1 is 2.2 kΩ. **2**



(ii) Describe a possible application for a circuit such as that shown above. **1**

(c) Describe the role of the electromagnet, pivot, switch contacts and insulator in a relay and explain the need for relays in an electronic device (eg a computer). **3**

Question 33 continues on page 28