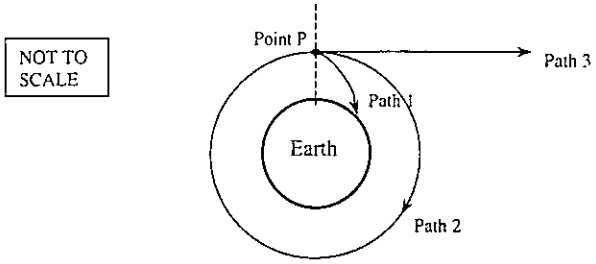
Independent 2001

STUDENT NUMBER/NAME: .....

1. A mass is projected horizontally from a point P above the Earth's surface. Three possible pathways are shown for this projectile.



If the projectile follows path 2, instead of the other paths, we can conclude that:

(A) Point P must have been above the equator
(B) The friction due to the atmosphere was too high for it to follow path 1
(C) The horizontal velocity of the projectile was too low for it to follow path 3
(D) The projectile experienced no gravitational pull towards the Earth because point P is too far above the Earth's surface.

2. Name the scientist that first put forward the idea that projectile motion was the resultant of two component motions at right angles to each other.

(A) Einstein
(B) Galileo
(C) Kepler
(D) Newton

3. Rocket ship Alpha has a mass of 14 500 kg as measured on Earth. Rocket ship Alpha then travels out across space and positions itself near a wormhole where its weight is measured as 7.28×10^7 N. What is the acceleration due to gravity near the wormhole?

(A) 5.02×10^3 m s^{-2}
(B) 1.06×10^{12} m s^{-2}
(C) 1.99×10^{-4} m s^{-2}
(D) 2.00×10^{-2} m s^{-2}

STUDENT NUMBER/NAME: .....

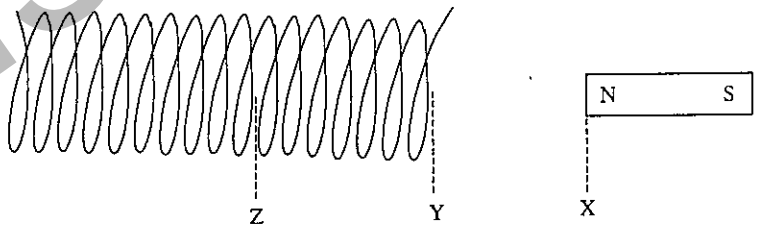
4. Kepler's Law of Periods $T^2 = kr^3$ shows the relationship between the period and the orbital radius of a planet that revolves around a star. The value k, a constant, can be changed by varying:

(A) the period of the planet
(B) the orbital radius of the planet
(C) the mass of the planet
(D) the mass of the star

5. The Russian space station which was orbiting Earth for many years eventually crashed into the Earth. This occurred because of:

(A) a reduction in its orbital velocity due to friction from the magnetosphere
(B) a reduction in its orbital velocity due to friction from the atmosphere
(C) an increase in its orbital velocity due to a stronger gravitational force
(D) a reduction in its orbital velocity causing the gravitational force to increase

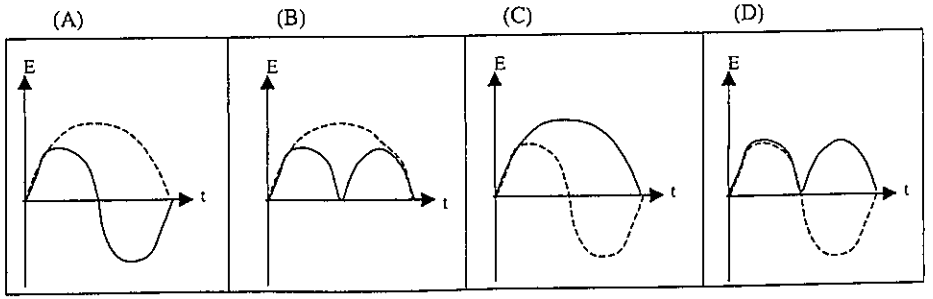
6. Two experiments are performed with a coil and a magnet.



Experiment 1: Magnet moved from X to Y, then back to X
Experiment 2: Magnet moved from X through Y to Z
(The magnet was stationary at the beginning and at the end of each experiment)

Which of the following graphs of induced emf in the coil vs time best illustrates the experimental results?

Experiment 1 ——— Experiment 2 -------



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7. Eddy currents occur in circuits as a result of Lenz's Law. Sometimes these eddy currents are a nuisance and cause loss of efficiency. At other times devices have been designed which specifically make use of eddy currents. Which of the following devices works on the principle of eddy current production?

(A) a transformer
(B) a resistor
(C) an electric motor
(D) a braking device in a roller coaster

8. A heavy load is being lifted using an electric motor to raise a cable attached to the load. The useful energy transformations involved in this procedure are:

(A) electrical energy → kinetic energy → gravitational potential energy
(B) electrical energy → heat energy → gravitational potential energy
(C) electrical energy → magnetic energy → kinetic energy
(D) electrical energy → gravitational potential energy → kinetic energy

9. Two long parallel conductors carry equal currents in opposite directions. The force between them is 3F.

The current in one of the conductors is doubled, but the current in the other is reduced to a third of its original value. The distance between the conductors is halved.

The new force between the conductors is closest to:

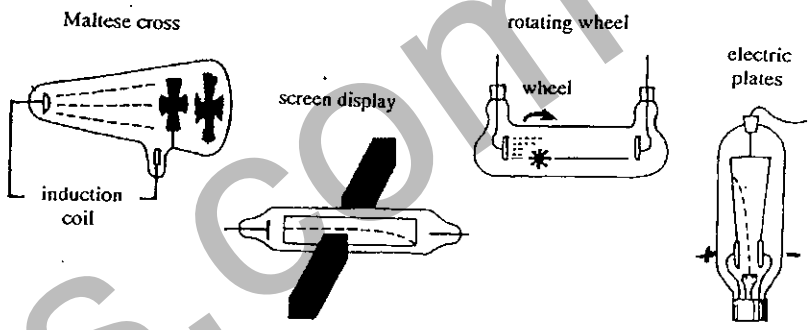
(A) 2F
(B) 4F
(C) 8F
(D) 16F

10. A set of Christmas tree lights requires 36 V A.C. to operate. They are connected through a transformer to the household 240 V A.C. supply.

If there are 320 turns in the primary coil of the transformer, the number of turns in the secondary coil is:

(A) 16
(B) 27
(C) 36
(D) 48

11. This question refers to the following diagram which shows how some of the properties of cathode rays are demonstrated using assorted discharge tubes connected to an induction coil.



Those properties of cathode rays which can be deduced from these demonstrations are:

(A) Cathode rays: travel in straight lines
are negatively charged
have energy and momentum

(B) Cathode rays: are electromagnetic
can be easily deflected from travelling in straight lines
do not penetrate solids

(C) Cathode rays: are fast moving electrons
cause fluorescence on impact with solids
require high voltage electric fields in which to be observed

(D) Cathode rays: have energy but no mass
remain undeflected travelling in the Earth's gravitational field
are more affected by magnetic and electric fields

12. Hertz's experiments with radio waves provided convincing evidence that:

(A) light rays travel at 3×10^8 m s^{-1}
(B) radio waves are electromagnetic waves
(C) light is a form of electromagnetic radiation
(D) there are many frequencies of radio waves

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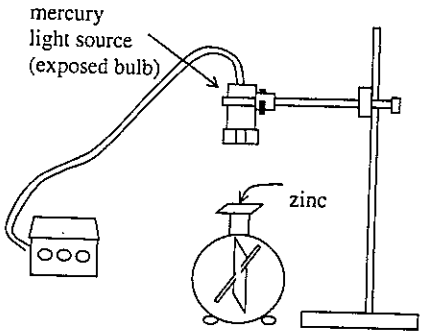
13. When a negatively charged electroscope surmounted by a piece of zinc is illuminated with ultraviolet light, the electroscope is observed to discharge rather rapidly.



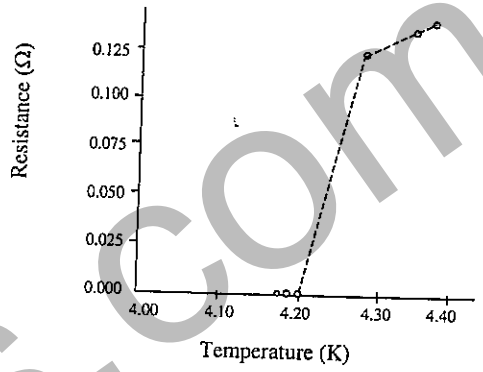
The observation is explained by:

(A) a chemical reaction occurred between the zinc and the radiation
(B) the radiation caused the air surrounding the electroscope to become positively ionised
(C) ultraviolet radiation is positively charged
(D) the radiation caused the zinc to lose negative charges

14. In semiconductors, the energy gap between the valence band and the conduction band is:

(A) equal to the energy of electrons that occupy the valence band
(B) very small because they are poor conductors at low temperatures
(C) very small so some electrons can be excited to the conduction band at normal temperatures
(D) equal to the energy of electrons that occupy the conduction band

15. The graph below shows the electrical resistance of the metal mercury plotted against temperature.



From the graph we can conclude that

(A) mercury is a superconductor of electricity above 4.20 degrees Kelvin
(B) mercury is a superconductor of electricity below 4.20 degrees Kelvin
(C) the conductivity of mercury drops to zero below 4.20 degrees Kelvin
(D) the electrical resistance of mercury can only be extrapolated from the graph below 4.20 degrees Kelvin.

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Section I

Part B

Total marks (60)
Attempt questions 16 – 26
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided

Question 16 (5 marks) **Marks**

(a) Explain the difference between a satellite that has a geostationary orbit and one that has a low earth orbit. **2**

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(b) What is ONE advantage of a geostationary satellite over a low earth orbiting satellite? **1**

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(c) Give an example of an application where scientists would choose to use a low earth orbiting satellite over a geostationary satellite. Explain why they would choose the low earth orbiting satellite for this particular application. **1**

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(d) State ONE safety precaution that should be taken when a satellite eventually crashes back to Earth? **1**

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Question 17 (4 marks) **Marks**

Describe an investigation which you carried out in class which demonstrates the changes in the motion of a satellite as it gets closer to its parent body. In your answer, describe what occurs to the satellite's motion and describe how this result can be tested or validated using real satellites. **4**

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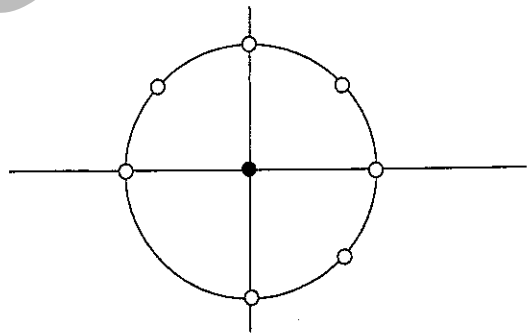
Question 18 (4 marks)

A satellite's position is being monitored once every 2 hours. A copy of the plot of its position relative to Earth is shown below.



(a) What is the minimum length of time indicated by the plot? **1**

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(b) It was decided to increase the monitoring of the satellite to once every hour. Indicate on the diagram what position you would expect the next three images of the satellite to appear in, if no change was made to the satellite's control system. **1**

(c) Discuss TWO important design elements required in a spacecraft if it is to allow safe re-entry to the atmosphere for the astronauts on board. **2**

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Question 19 (5 marks) **Marks**

(a) What are the van Allen radiation belts? **2**

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(b) Why are they so important to life on Earth? **1**

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(c) Explain how changes in sun spot activity can produce changes in the van Allen Belts. **1**

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(d) Why do these changes in the van Allen belts cause communication problems between Earth and its satellites? **1**

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Question 20 (2 marks)

The evaluation of a scientific theory is based on the experimental evidence sustaining the theory.

Describe ONE experiment that has verified Einstein's theory of time dilation. **2**

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Question 21 (2 marks) **Marks**

A transformer consists of two coils which are electrically insulated from each other, but wound on the same core. The core consists of several thin sheets (*laminations*) of soft iron that are insulated from each other.

Explain why the core is constructed like this. **2**

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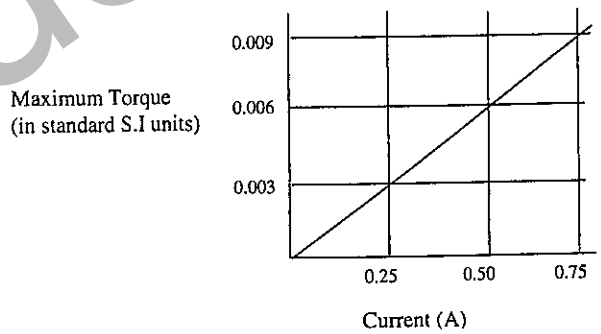
Question 22 (3 marks)

A rectangular coil of sides 2.0 cm and 6.0 cm is placed in a uniform magnetic field of strength 0.1 Tesla. The current in the coil is steadily increased, and the maximum torque acting on the coil is measured. The following graph was obtained from the results.



(a) What is the standard S.I. unit for torque? **1**

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(b) Clearly showing your working, determine the number of turns of wire in the coil. **2**

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Question 23 (2 marks) **Marks**

Describe TWO features of an A.C. generator which contribute to it being more efficient than a D.C. generator. **2**

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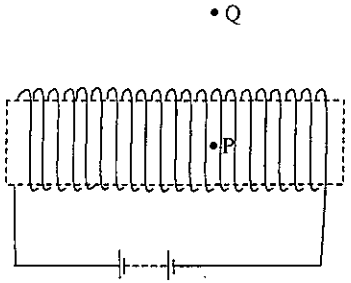
Question 24 (2 marks)

A coil is wound on a cardboard cylinder.



The ends of the wire are connected to a battery, producing a magnetic field in and around the coil.

Compare the size and direction of the field at points P and Q **2**

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Question 25 (5 marks) **Marks**

(a) Describe how electrical energy is transmitted from a power station to a domestic consumer.

Your description should clearly describe the changes which occur in the voltage and current. **3**

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(b) What is the main source of energy loss in this transmission? Explain how the changes in voltage and/or current that you have described help to minimise this energy loss. **2**

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Question 26 (3 marks) **Marks**

A square coil is moved out of a magnetic field as shown, inducing an emf between the ends of the coil.

Diagram 1 (time = 0)

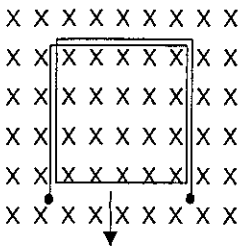
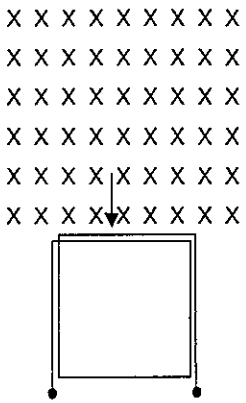


Diagram 2 (time = t)



Describe THREE ways in which this experiment could be modified so that a larger emf was induced between the ends of the coil. **3**

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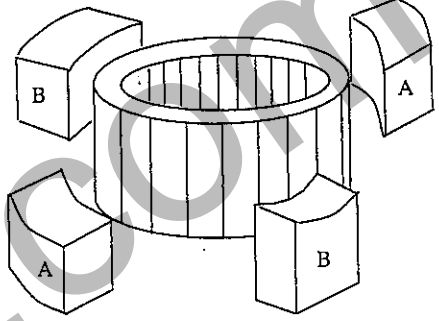
Question 27 (3 marks) **Marks)**

In an A.C. induction motor the "squirrel cage" rotor is a copper cylindrical cage, mounted in a region where magnetic fields can be applied from two or three sets of electromagnets. The diagram below shows two sets labelled A and B.



(a) Alternating current is supplied to both sets A and B. What is different about the current supplied to A and B? **1**

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(b) Explain the advantages of induction motors (over conventional A.C. motors). **2**

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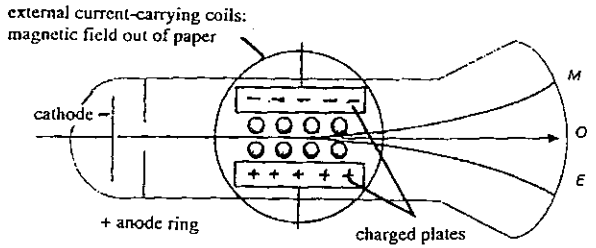
Question 28 (5 marks) **Marks**

(a) Towards the end of the 19th century, the English physicist JJ Thomson was able to add to the knowledge of cathode rays by his investigations into their charge to mass ratio. **3**

A simplified diagram of Thomson's experimental cathode ray tube is shown below.



Thomson's observations included the following:

- when a cathode ray beam is subjected to an electric field only, it is deflected such that the position marked E at the end of the tube glows
- when a cathode ray beam is subjected to a magnetic field only, it is deflected such that the position marked M glows
- when a cathode ray beam is subjected to both electric and magnetic fields, the beam is not deflected and the position at the end of the tube marked O glows

(i) Use your understanding of the nature of cathode rays to explain these observations.

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(ii) Use your understanding of the behaviour of cathode rays in electric and magnetic force fields to outline how Thomson measured the value $\frac{q}{m}$, where q is the charge of the particle, of mass m moving with a speed v in a magnetic field B and electric field E, and travelling in a circular path of radius r.

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Question 28 continued on next page

(Question 28 continued) **Marks**

(b) A television picture tube is a modern day application of cathode rays moving in an evacuated glass container.

Explain how deflection of the cathode rays is achieved differently in a television picture tube compared with a cathode ray oscilloscope (C.R.O.) **2**

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Question 29 (3 marks)

(a) Draw a labelled diagram to show the electric field between two parallel plates which have a potential difference applied between them. **2**

(b) If the potential difference between the plates is 2 kV, and the distance between them is 1.5 cm, find the magnitude of the electric field between them. **1**

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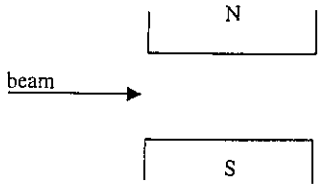
Question 30 (2 marks) **Marks**

A beam of cathode rays moving at 1×10^3 m s^{-1} passes at right angles through a magnetic field of intensity 0.5 T as shown:



Find the magnitude and direction of the force on each cathode ray particle. **2**

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Question 31 (2 marks)

How much energy does a photon of ultraviolet light of wavelength 1.6×10^{-7} m have? **2**

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STUDENT NUMBER/NAME: .....

Question 32 (3 marks) **Marks**

Outline the composition of the two main types of silicon semiconductors and explain how this gives rise to their electrical properties. **4**

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Question 33 (4 marks) **Marks**

(a) What is the photoelectric effect? **1**

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(b) Identify the photon postulates of Einstein that are used to explain how the photoelectric effect is dependent on the frequency of incident electromagnetic radiation. **2**

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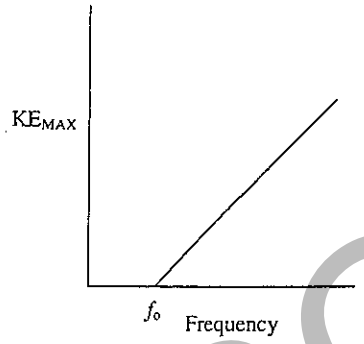
(c) The graph of maximum kinetic energy (of emitted electrons) vs frequency of radiation, shown below, was obtained when the polished surface of a metal was illuminated with light.



On the same axes above, sketch the kinetic energy vs frequency graph for a metal with a higher work function. **1**

Question 37 – Quantum to Quarks (25 marks) **Marks**

(a) (i) The Balmer series is the line emission spectrum for hydrogen with wavelengths in the visible light range. Sketch a series of lines to represent this spectrum labelling the red line and the end of the spectrum with the highest frequency. **2**

(ii) Outline the significance of the hydrogen line spectrum and the work of Max Planck in the development of Bohr's model of the atom. **3**

(iii) Calculate the wavelength of the spectral line produced when an excited electron moves from energy level 4 to energy level 2 **1**

(b) In this doctoral thesis Louis de Broglie proposed an unconventional view of the electron and his thesis was not accepted until Albert Einstein expressed approval of de Broglie's startling proposal.

(i) State de Broglie's proposal. **1**

(ii) Use his proposal to explain the stability of certain electron orbits in the Bohr atom. **2**

(iii) Describe how Davisson and Germer were able to provide evidence to support de Broglie's proposal. **3**

(c) The electron microscope has a greater resolving power than the light microscope.

(i) Explain why the electron microscope has a greater resolving power than the light microscope. **2**

(ii) Compare the impact of major advances in scientific knowledge that resulted from the development of each type of microscope. **3**

(d) (i) In a typical fission reaction, a neutron of thermal energy collides with a uranium U-235 nucleus. The product nuclei are barium and krypton and a number of neutrons. If the kinetic energy of the colliding neutron is negligible, calculate the energy in MeV carried away by the fission products. **3**

Mass of ^{235}U nucleus	=	235.0439 u
Mass of neutron	=	1.0087 u
Mass of ^{141}Ba nucleus	=	140.9139 u
Mass of ^{92}Kr nucleus	=	91.8973 u

(ii) In the last 50 years, the number of radioisotopes used has greatly increased. Name one radioisotope used in industry and describe its application. **2**

Question 37 – Quantum to Quarks is continued on next page

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Question 37 – Quantum to Quarks (continued)

(e) Physicists today are unlikely to suggest that their understanding of matter is complete. They believe that there are many discoveries to be made in the linked areas of cosmology and particle physics.

Compare Rutherford's model of the atom to the current model of the atom. 3

End of Question 37

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