TERTIARY ENTRANCE EXAMINATION, 1989

QUESTION/ANSWER BOOKLET

PHYSICS

Please place one of your student identification labels in this box

STUDENT SEA NUMBER—In figures | | | | | | | | |

In words _____

_____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing: Ten minutes
Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet comprising 41 pages (Section A - 30 questions, Section B - 8 questions)

TO BE PROVIDED BY THE CANDIDATE

Standard Items

Pens, pencils, eraser or correction fluid, ruler

Special Items

Hood & Storer Mathematical & Statistical Tables, Source Book of Chemical Data, OR the Combined Book of Mathematical & Statistical Tables and Chemical Data, a calculator satisfying the conditions set by the Secondary Education Authority, compass, protractor and set square.

NOTE: Personal copies of Tables/Chemical Data should not contain any handwritten or typewritten notes, symbols signs, formulae or any other marks (including underlining and highlighting), except the name and address of the candidate, and may be inspected during the examination.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. Please check carefully, and if you have any unauthorised material with you, hand it to the supervisor BEFORE reading any further.

SEE PAGE 3

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SEE PAGE 3

INSTRUCTIONS TO CANDIDATES

This paper consists of TWO (2) sections.

In SECTION A, answer ALL thirty questions, and **write your answers in the spaces provided beneath each question.** This section carries 48% of the total marks for the paper. Each of these questions is of equal value.

In SECTION B, answer ALL questions, and write your answers in the Question/Answer Booklet provided. This section is worth 52% of the total marks for the paper.

In both sections, note that all answers should be given numerically where possible, and that numerical answers should be evaluated and not left in fractional or radical form. Give all answers to three significant figures unless otherwise instructed.

A calculator satisfying the conditions set by the Secondary Education Authority and approved mathematical tables may be used to evaluate numerical answers.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

At the commencement of this examination, attach your STUDENT IDENTIFICATION label to the front cover of this Question/Answer Booklet. Write your student SEA number in the spaces provided in the Question/ Answer Booklet.

REFER TO PAGE 41 FOR PHYSICAL CONSTANTS

NOTE: Page 41 is perforated and may be removed for easier use during the examination.

SEE PAGE 4

SECTION A

MARKS ALLOTTED : 48

Attempt all thirty (30) questions in this section. All questions are worth equal marks. Answers are to be written in the spaces provided for each question below or next to the question.

Evaluate answers numerically where possible. Credit will be given for working, if shown. Numerical constants are listed on page 41.

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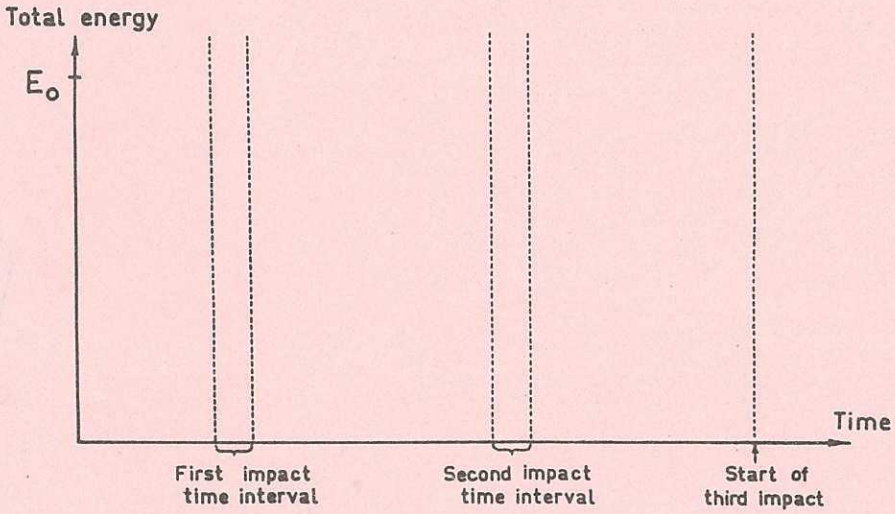
1. (a) Can three vectors of magnitude 1, 2 and 3 units respectively be combined to give a zero resultant? Sketch a diagram to justify your answer, showing clearly magnitudes and directions.

(b) Can two vectors having differing magnitudes be combined to give a zero resultant? Give reasons for your answer.

SEE PAGE 5

2. A rubber ball is dropped onto a concrete surface. Sketch the total energy of the ball from when it is dropped (t = 0) to the beginning of the third impact with the concrete surface. The collisions are inelastic.



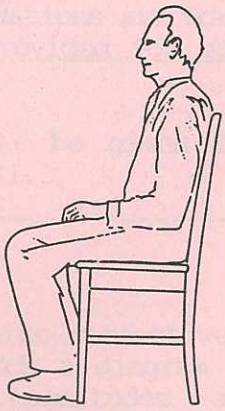
E_o = Initial total energy of the ball

3. A student wished to determine the area of a rectangle. The length and breadth of the rectangle were measured and values of (50·0 ± 0·5) mm and (10·0 ± 0·5) mm respectively were obtained. In the laboratory write-up the student recorded the area as 500 mm^2.

How should this area have been reported to take into account the errors in the length and breadth measurements?

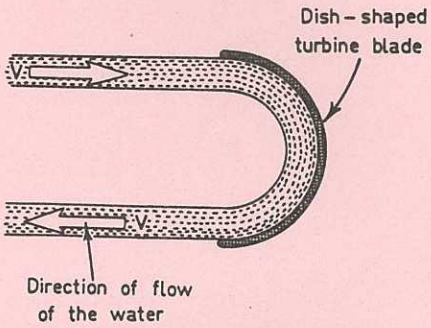
SEE PAGE 6

4. Explain why it is impossible to move from a sitting position in a straight-backed chair to a standing position without first leaning forward? Use the diagram below to assist with your explanation.



5. A stream of water strikes a stationary dish-shaped turbine blade as shown in the diagram below. The speed of the water both before and after it strikes the curved surface of the blade has a constant value of v. The mass of water striking the blade per unit time is S.

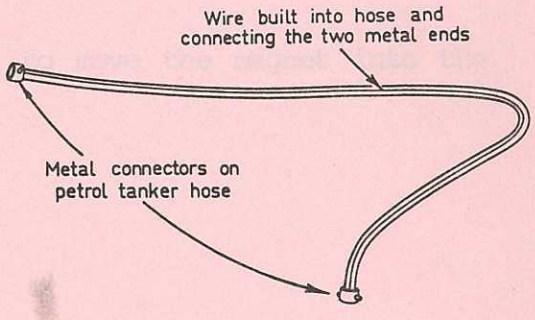
Find an expression for the magnitude of the force exerted by the water on the blade in terms of S and v.



SEE PAGE 7

6. What is the reaction force of the road on a car of mass $1{\cdot}05 \times 10^3$ kg travelling at 90·0 km h^{-1} (kilometres per hour) over the crest of a hill? Assume the hill forms part of a circle of radius 80·0 m.

7. The filling hoses used to transfer petrol from petrol tankers to underground petrol storage tanks at service stations have a thick conducting wire built into them. These are regularly checked to ensure they conduct electricity. Explain why these hoses are designed this way.



SEE PAGE 8

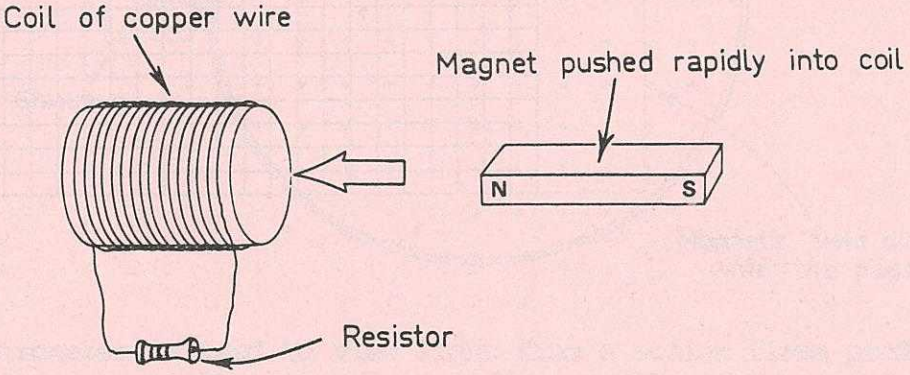
8. Sketch the pattern of electric field lines surrounding two point charges of +q and +3q units of charge as shown. No calculation is required.

9. The charged sphere of a Van de Graaff generator is at a negative potential of 1·30 MV. What power is required to transfer $1{\cdot}00 \times 10^6$ electrons per second from a region which is at earth potential to the sphere?

SEE PAGE 9

10. A steady current is flowing in a resistor. A charge of 15·0 C is observed to pass for 3·00 s during which time the potential difference across the resistor has a constant value of 4·50 V. What is the resistance of this resistor?

11. A bar magnet is thrust into a coil across which a resistor is connected as shown.

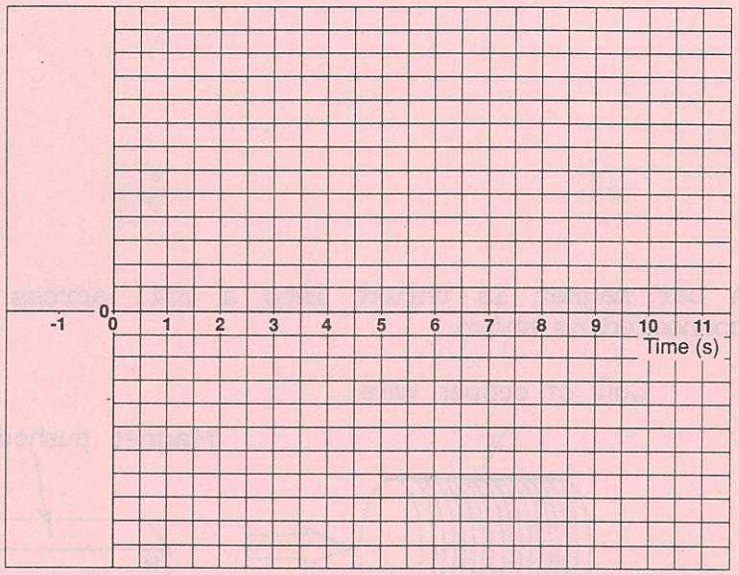


(a) Explain why work must be done to move the magnet into the coil.

(b) Describe energy transitions that occur in this system.

SEE PAGE 10

12. A coil of $5{\cdot}00 \times 10^2$ turns and area $1{\cdot}00 \times 10^{-4}$ m^2 is situated in a constant magnetic field of density 0·300 Wb m^{-2}. At t = 0 the field is increased at a uniform rate from its initial value to 0·800 Wb m^{-2} in 5·00 s, and is held at that value thereafter. On the axes provided below plot a graph to show how the emf induced in the coil varies with time before, during and after the field is increased. Place a suitable label and scale on the vertical axis of your graph.



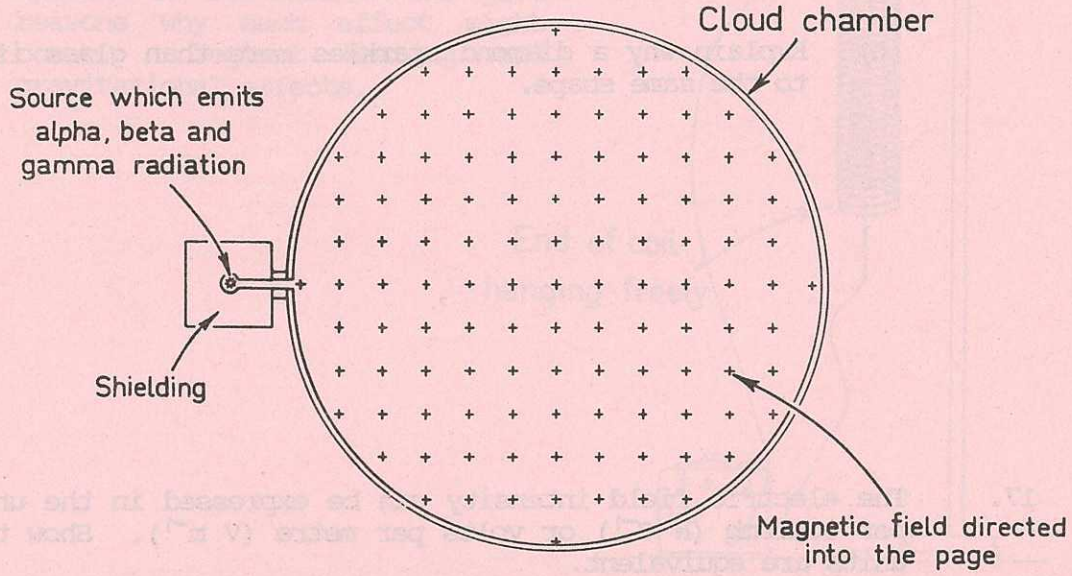
13. Define the term isotope and use the two isotopes of carbon (atomic number 6), ^{12}C and ^{14}C, to illustrate your definition.

SEE PAGE 11

14. A source of radiation which emits alpha, beta and gamma radiation is placed so the radiation passes into a cloud chamber which has a magnetic field directed into the page as shown. On this diagram

- draw the paths produced by each of these radiations as they pass through the chamber and
- indicate the relative intensity of the tracks left by each.

Label your diagram fully.



15. A spectrometer is used to view light from a sodium flame produced by heating common salt in a bunsen flame. The spectrum shows two prominent yellow lines which are closely spaced at wavelengths of 589·0 nm and 589·6 nm. These lines are due to electron transitions from two closely spaced energy levels down to the same lower energy level. Calculate the energy difference between these two closely spaced levels in eV.

SEE PAGE 12

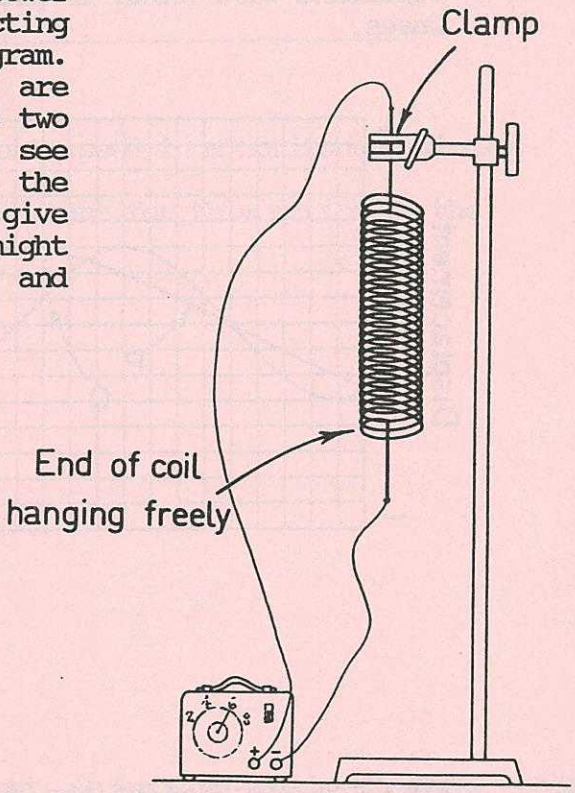
16. (a) The critical angle of diamond in air is 27·0° for yellow light. What is the absolute refractive index of diamond assuming the speed of yellow light in air is the same as it is in a vacuum?

(b) Explain why a diamond sparkles more than glass if both are cut to the same shape.

17. The electric field intensity can be expressed in the units of newton per coulomb ($N\ C^{-1}$) or volts per metre ($V\ m^{-1}$). Show that these two units are equivalent.

SEE PAGE 13

18. A flexible wire is wound into a coil and held fastened by one end in a clamp. The two ends of the coil are connected to a power supply using very thin conducting wires as shown in the diagram. The retort stand and clamp are made from aluminium. State two effects which you might see happen to the coil when the current is switched on and give reasons why each effect might occur. Neglect heating and gravitational effects.



(a) Possible effect 1 _____

_____

Explanation _____

_____

_____

_____

(b) Possible effect 2 _____

_____

Explanation _____

_____

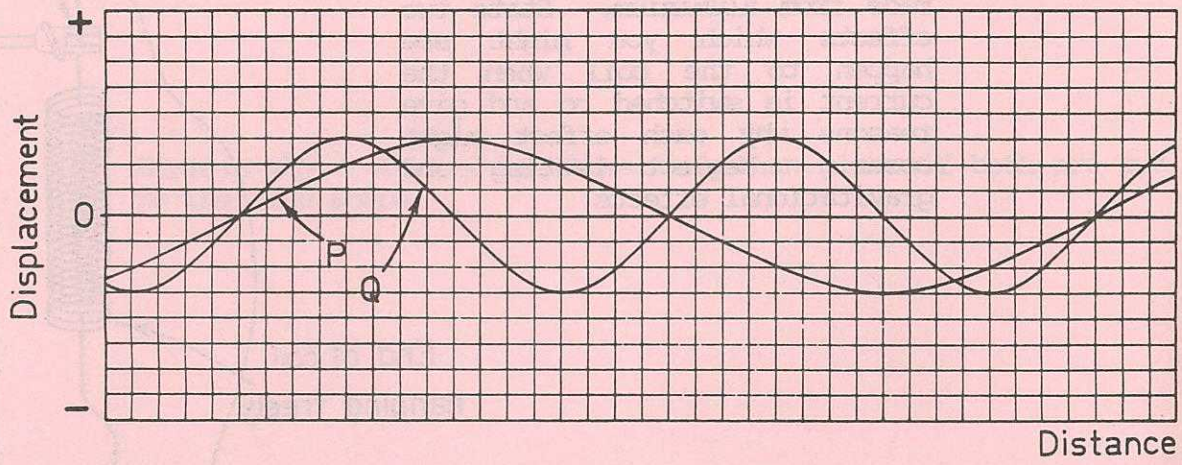
_____

_____

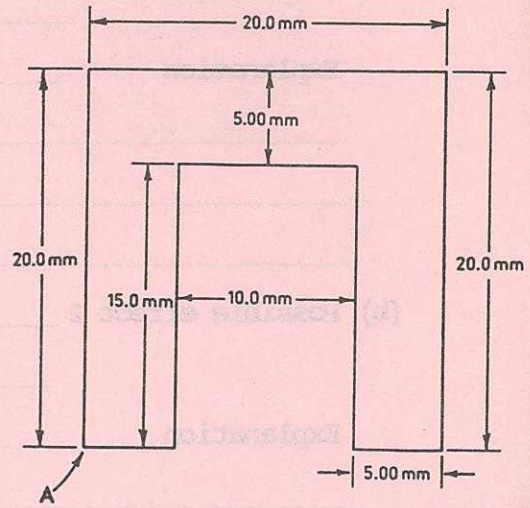
_____

SEE PAGE 14

19. The displacement at a given instant due to two waves P and Q which pass simultaneously through the same medium with equal velocities are illustrated on the graph below. On the same graph sketch the resultant wave which is produced from the interaction of these two waves.



20. Find the position of the centre of mass of the lamina (such as a very thin flat piece of metal) shown below. Assume the lamina has uniform density. Give the position of the centre of mass with reference to point A.



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For the next ten questions, choose which of the alternatives best answer the questions and indicate your choice by writing the appropriate letter in the box provided.

21. An object travels with constant speed in a horizontal circle.

One other quantity that is constant for this motion is the

A. momentum.

B. acceleration.

C. displacement.

D. kinetic energy.

E. centripetal force.

22. An aircraft in level flight is moving with constant velocity relative to the ground. The net force acting on the aircraft is equal to

A. zero because the vertical forces cancel and the horizontal forces cancel.

B. the resistive push of the air on the aircraft (air resistance).

C. the pull of the earth on the aircraft (weight).

D. the resultant of the air resistance and the push of the engines on the aircraft.

E. the resultant of the air resistance and the weight of the aircraft.

SEE PAGE 16

23. Suppose a planet exists that has half the mass and half the radius of the Earth. On the surface of that planet the acceleration due to gravity is

A. half that on Earth.

B. the same as that on Earth.

C. twice that on Earth.

D. one quarter that on Earth.

E. four times that on Earth.

24. The magnitude of the torque of force F about point A is

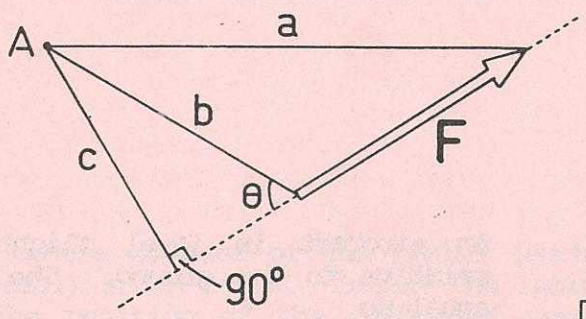
A. F x a.

B. F x b.

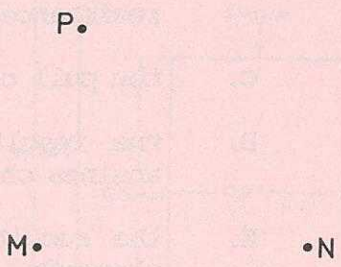
C. F x c cos θ.

D. F x b cos θ.

E. F x b sin θ.



25. When a charge of +q is placed at M the field strength at P is $\vec{E}_1$. When the same charge is placed at N the field strength at P is $\vec{E}_2$. If two charges of +q are now placed, one at M and the other at N, then the field strength at P will have a magnitude which is



A. the sum of the magnitudes of $\vec{E}_1$ and $\vec{E}_2$.

B. the magnitude of the vector sum $(\vec{E}_1 + \vec{E}_2)$.

C. less than the magnitude of the vector sum $(\vec{E}_1 + \vec{E}_2)$.

D. greater than the sum of the magnitudes of $\vec{E}_1$ and $\vec{E}_2$.

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26. An electron enters a region where there is a uniform electric field. It is observed that the electron velocity decreases in magnitude but is unchanged in direction as it moves in the field. The electron was moving

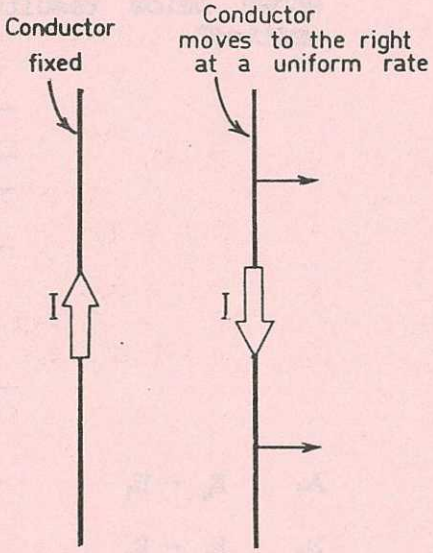
A. perpendicular to the field.

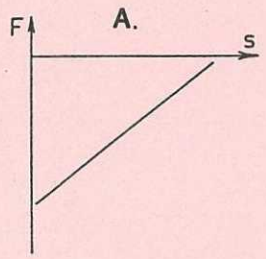
B. parallel and in the opposite direction to the field.

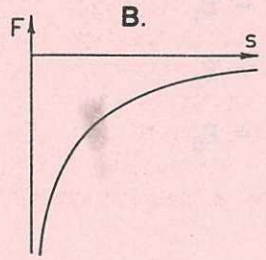
C. parallel and in the same direction as the field.

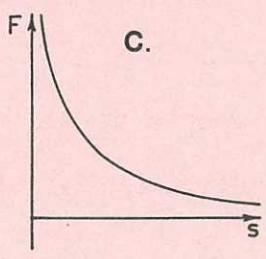
D. at an oblique angle to the field.

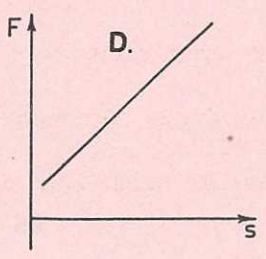
27. Two parallel conductors are situated fairly close together and carry currents in opposite directions as shown in the diagram. If the distance separating them is steadily increased by moving the right hand conductor away from the fixed left hand conductor, which graph best illustrates the way the force on the left hand conductor varies due to the current between the conductors? Forces to the right are positive and to the left are negative.











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28. The nuclear binding energy of a nucleus may be defined as

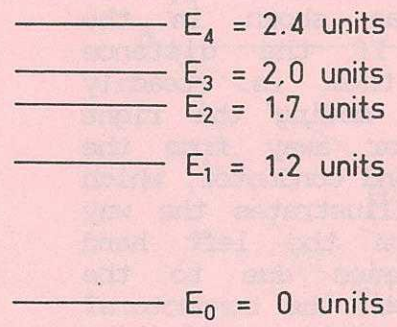
A. the mass of the individual particles of the nucleus.

B. the energy required to bind the protons of a nucleus together.

C. the energy released when protons and neutrons join to form a stable nucleus.

D. the energy released in a fission or fusion reaction.

29. Which transition associated with the atom with energy levels as shown below results in the longest wavelength radiation being emitted?



A. $E_4 - E_1$

B. $E_4 - E_2$

C. $E_4 - E_3$

D. $E_3 - E_2$

E. $E_4 - E_0$

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30. Radioactive carbon, $^{14}_{6}C$, decays with a half-life of 5730 years to nitrogen, $^{14}_{7}N$. Which particle is released in this decay process?

A. A proton

B. A deuteron

C. A beta particle

D. An alpha particle

E. A gamma ray

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SECTION B

MARKS ALLOTTED : 52

Attempt ALL questions from this section. Credit will be obtained for method and reasoning only if these are clearly shown. Answers should be evaluated numerically. Numerical constants which may be required are listed on page 41 and/or within the question itself.

[6 marks]

1. A horizontal uniform plank XC of length 2·00 m is held in place by two pegs A and B as shown. Peg A is 0·250 m from the end X of the plank XC. Peg B is 0·500 m from end X.

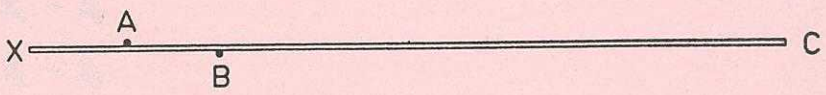
   The mass of the plank is 10·0 kg. Determine the magnitude and direction of

   (a) the force of peg A on the plank.

   (b) the force of peg B on the plank.

   (c) the force of the plank on peg A.

   (d) the force of the plank on peg B.



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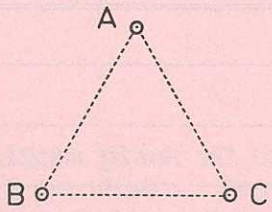
[6 marks]

2. Equal charges of +3·00 μC are placed at the vertices of an equilateral triangle as shown below.



AB = BC = AC = 50·0 mm

(a) Calculate the magnitude and direction of the resultant force on the charge at A due to charges B and C.

(b) Calculate the magnitude and direction of the electric field at vertex A due to the charges at B and C.

(c) On the diagram above show clearly the magnitude and direction of the resultant net forces on each of the three charges.

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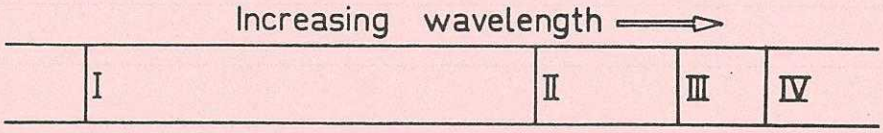
[6 marks]

3. The figure below shows parts of the emission spectrum of an element.



Light corresponding to the above frequencies is used to illuminate the metal cathode plate of a photoelectric cell. In some cases photoelectrons are ejected from the metal and in others they are not.

(a) Which one of the above spectral lines is most likely to eject photoelectrons from the plate? Give a reason for your answer.

(b) Light of frequency $7{\cdot}14 \times 10^{14}$ Hz can eject electrons with a kinetic energy of $0{\cdot}480 \times 10^{-19}$ J from the metal plate. What is the work function of this metal?

(c) Line III corresponds to a frequency of $5{\cdot}28 \times 10^{14}$ Hz. Show whether light of this frequency is capable of ejecting electrons from this metal.

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[6 marks]

4. The current in a resistor varies with time t(s) according to the equation

$$I = 10{\cdot}0 - 2{\cdot}00t$$

when current is measured in amperes.

(a) On the graph paper on the opposite page plot a graph to show the value of the current between t = 0·00 s and t = 8·00 s.

(b) Calculate how much charge is passed in the period between t = 2·00 s and t = 4·00 s.

(c) Determine the power generated in the resistor when t = 5·00 s if the resistor has a resistance of 2·00 Ω.

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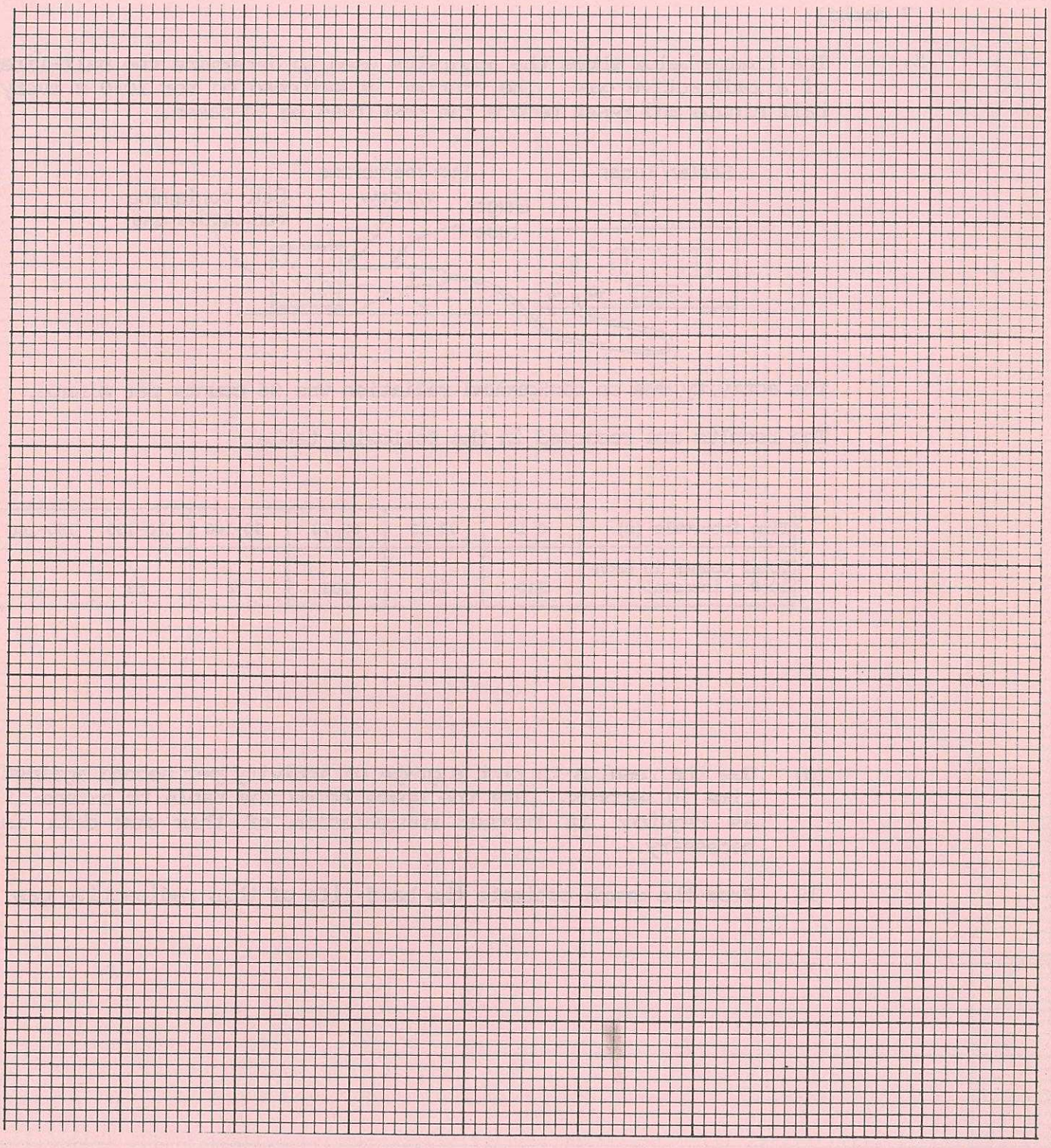

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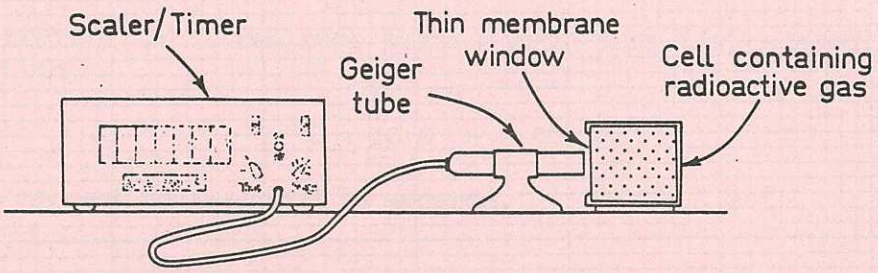
[7 marks]

5. The figure below shows the apparatus used to determine the half-life of a radioactive gas. The counter is switched on for 10·0 s every half minute and reset before the next reading is taken.



The activity due to background radiation was 96 counts per minute.

The results are recorded in the following table

Time intervals (s)	0–10	30–40	60–70	90–100	120–130	150–160
Total counts in each 10·0 s interval	210	145	108	78	53	41

(a) Use the results to plot a graph of activity per second against time in seconds. Use the space below the table to extend it as required if further manipulation of this raw data is necessary.

(b) From the graph estimate the half-life of this radioactive gas.

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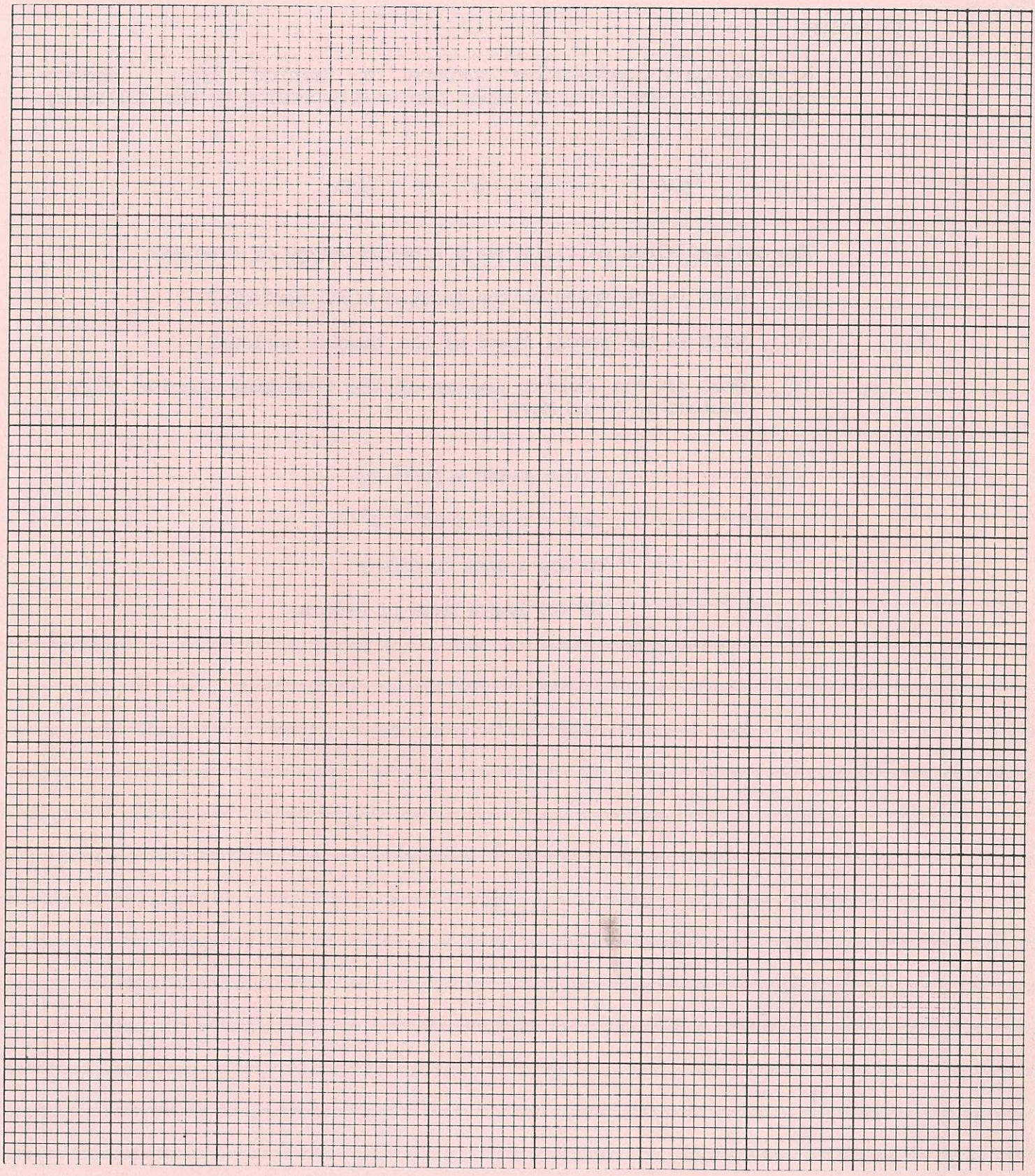

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[7 marks]

6. A stationary radioactive nucleus of uranium ($^{235}_{92}U$) decays spontaneously emitting an alpha particle according to the following equation

$$^{235}_{92}U \longrightarrow \alpha + {}^{231}_{90}Th$$

The emitted alpha particle has a kinetic energy of 4·60 MeV.

(a) What is the speed of the emitted alpha particle?

(b) What is the recoil speed of the thorium nucleus?

(c) What is the kinetic energy of the recoiling thorium ($^{231}_{90}Th$) nucleus in J and Mev?

$1\ u = 1{\cdot}660 \times 10^{-27}$ kg

$1eV = 1{\cdot}602 \times 10^{-19}$ J

^{231}Th has a mass of 231 u

^{4}He (α) has a mass of 4·00 u

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[7 marks]

7. An electron is accelerated from rest through a potential difference of 20·0 kV and enters a region where a uniform magnetic field of 0·200 T is at right angles to the path of the electron.

(a) What is the magnitude and direction of the acceleration of the electron in the magnetic field?

(b) Explain why the resulting path of the electron in the field is circular.

(c) Assuming the electron remains in the magnetic field how long will it take to execute one complete circle?

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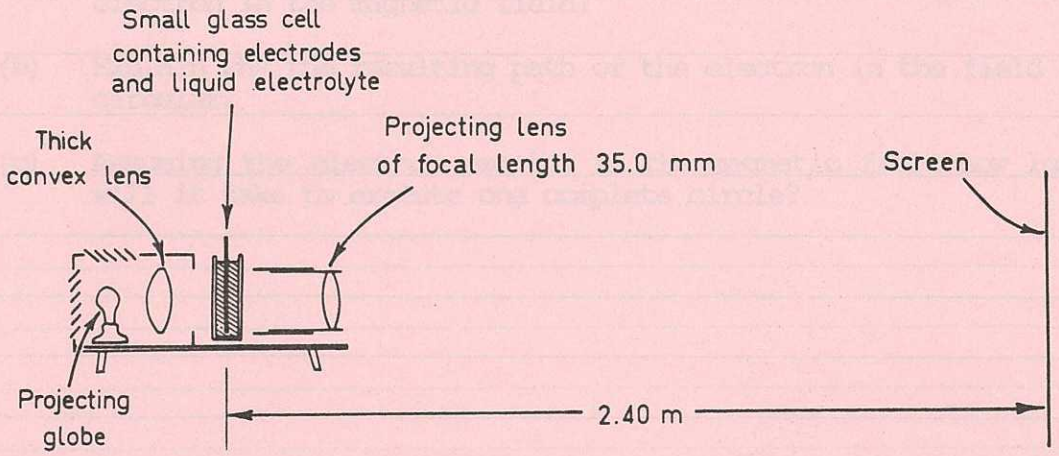
[7 marks]

8. A small electrochemical cell is to be used in the slide holder of a slide projector so the chemical reaction occurring in the cell can be observed by a class. A diagram of the arrangement is shown below.



(a) The designers of the projector require that parallel rays pass through the slide (or cell). Explain how this is achieved using the arrangement shown.

(b) If the slide to screen distance is 2·40 m and the focussing lens has a focal length of 35·0 mm, calculate the distance from this lens to the centre of the slide when the enlarged image of the object is focussed on the screen.

(c) Students observe coloured fringes in the image on the screen. State the name given to this effect and explain what causes it to occur.

(d) A problem with this demonstration is that the image appears upside down on the screen (and students may think the liquid might flow out of the cell and that bubbles produced fall downward!). Sketch a diagram showing how, with the use of some additional optical components, you could reinvert the image.

END OF QUESTIONS

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