ieb assessment matters

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TOTAL MARKS

NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2022

PHYSICAL SCIENCES: PAPER I

EXAMINATION NUMBER

Time: 3 hours

200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 31 pages and a Data Sheet of 2 pages (i–ii). Please check that your question paper is complete.
2. Read the questions carefully.
3. Answer ALL the questions on the question paper and hand it in at the end of the examination. Remember to write your examination number in the space provided above.
4. Use the data and formulae whenever necessary.
5. Show your working in all calculations.
6. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.
7. Answers must be expressed in decimal format, not left as proper fractions.
8. Where appropriate, express answers to TWO decimal places.
9. It is in your own interest to write legibly and to present your work neatly.
10. TWO blank pages (pages 29–30) are included at the end of the paper. If you run out of space for a question, use these pages. Clearly indicate the number of your answer should you use this extra space. There is a spare copy of graph paper on page 31.

FOR OFFICE USE ONLY: MARKER TO ENTER MARKS

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
Mark											
Marker Initial											
Moderated Mark											
Moderator Initial											
Question Total	20	20	14	16	14	27	24	30	20	15	200
Re-mark											
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QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice answer grid below. Make a clear cross (X) in the box corresponding to the letter that you consider to be correct. Every question has only one correct answer.

A	B	C	D

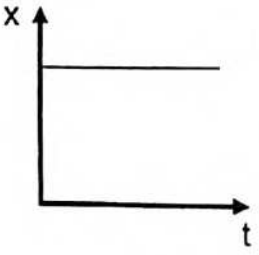
Here the option C has been marked as an example.

	A	B	C	D
1.1				
1.2				
1.3				
1.4				
1.5				
1.6				
1.7				
1.8				
1.9				
1.10				

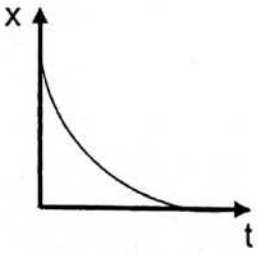
1.1 Which option contains both a scalar and a vector quantity?

A mass and momentum
B electric charge and speed
C acceleration and electric field
D gravitational potential energy and work

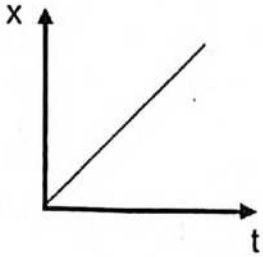
1.2 Which of the following position–time graphs represent the motion of an object moving with constant, non-zero velocity?



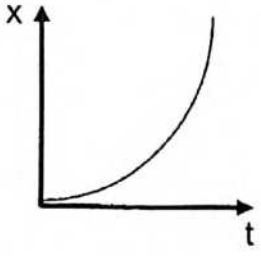
A



B



C

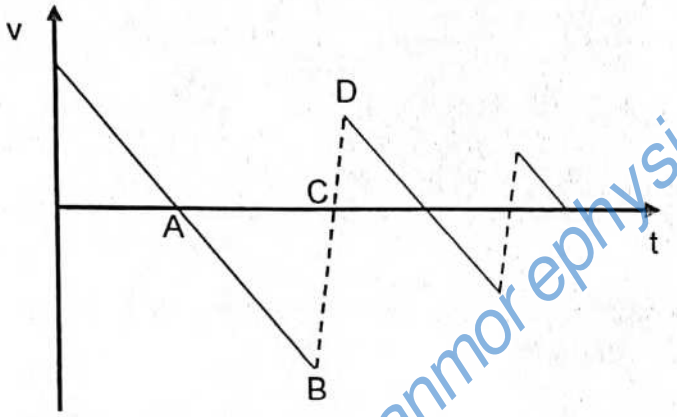


D

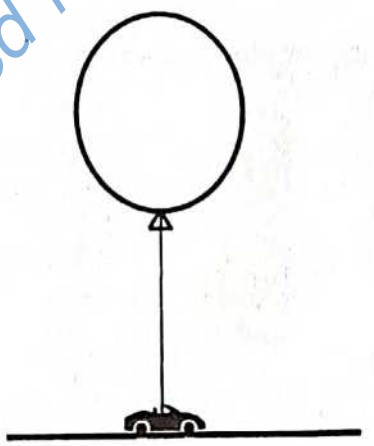
1.3 Two identical small metal balls are at the same height above the ground. Ball A is dropped. Ball B is thrown downwards. Which statement is true?

A Ball B will take less time to reach the ground than ball A.
B Ball B will hit the ground with a smaller velocity than ball A.
C While they are in the air, the acceleration of ball B will be greater than the acceleration of ball A.
D While they are in the air, the acceleration of ball A will be greater than the acceleration of ball B.

1.4 An object is initially thrown upwards. It hits the ground for the first time at the moment marked ...



1.5 A small toy is attached to a balloon filled with helium. The balloon applies an upward force on the toy, but the toy remains resting on the ground.



Which statement is true about the forces acting on the toy?

A normal force = gravitational force
B normal force > gravitational force
C normal force < gravitational force
D upward force by the balloon = gravitational force

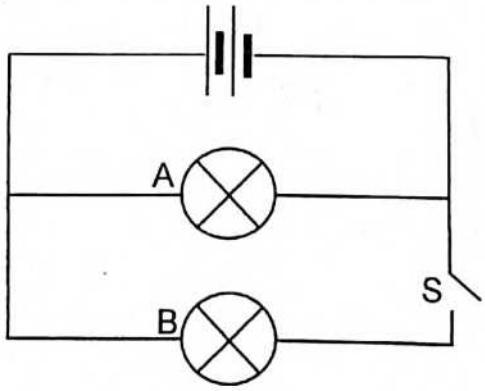
1.6 Four collisions are shown in the table below. The two blocks colliding each have a mass of 2 kg. Which collision is possible and is perfectly elastic?

	before collision	after collision
A	$3\ m{\cdot}s^{-1}$ → ▭ ▭ ← $3\ m{\cdot}s^{-1}$	▭▭ $0\ m{\cdot}s^{-1}$
B	$2\ m{\cdot}s^{-1}$ → ▭ ▭ $0\ m{\cdot}s^{-1}$	▭▭ → $1\ m{\cdot}s^{-1}$
C	$3\ m{\cdot}s^{-1}$ → ▭ ▭ ← $1\ m{\cdot}s^{-1}$	$0\ m{\cdot}s^{-1}$ ▭ ▭ → $4\ m{\cdot}s^{-1}$
D	$3\ m{\cdot}s^{-1}$ → ▭ ▭ → $1\ m{\cdot}s^{-1}$	$1\ m{\cdot}s^{-1}$ → ▭ ▭ → $3\ m{\cdot}s^{-1}$

1.7 A motor uses energy at a rate of 200 W while raising a load. It is 25% efficient. At what rate will the load gain energy?

A 50 W
B 150 W
C 800 W
D 1 600 W

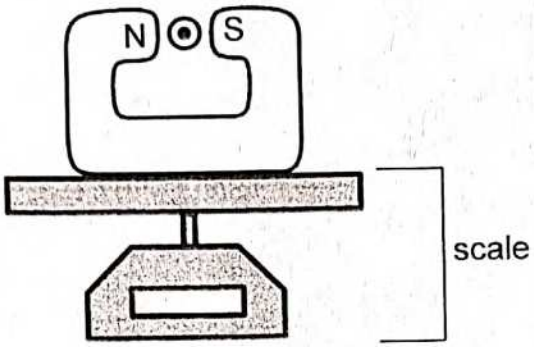
1.8 Two identical bulbs are connected to a battery with negligible internal resistance. Switch S is open.



When the switch is closed, bulb A …

A begins to glow.
B increases in brightness.
C decreases in brightness.
D remains the same brightness as when switch S was open.

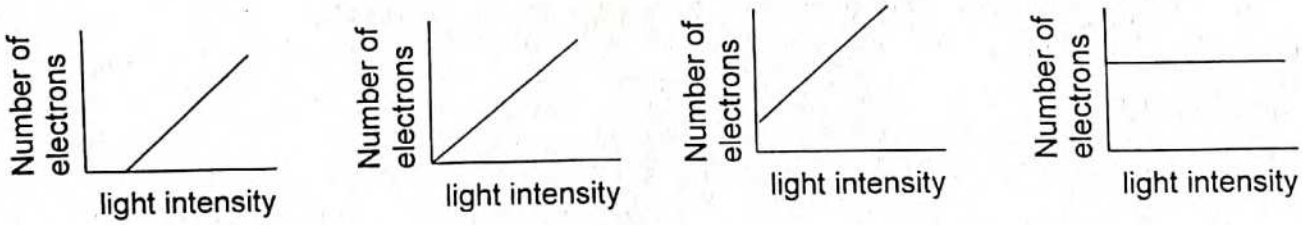
1.9 A horseshoe magnet rests on a scale. A current-carrying conductor is placed between the poles of the magnet, with the current directed out of the page, as shown. What will happen to the force on the conductor and the reading on the scale when the current in the conductor increases?



	Force on conductor	Reading on scale
A	Decreases	Decreases
B	Decreases	Increases
C	Increases	Decreases
D	Increases	Increases

1.10 High-energy light is shone onto a zinc plate. The energy of the light is greater than the work function of zinc.

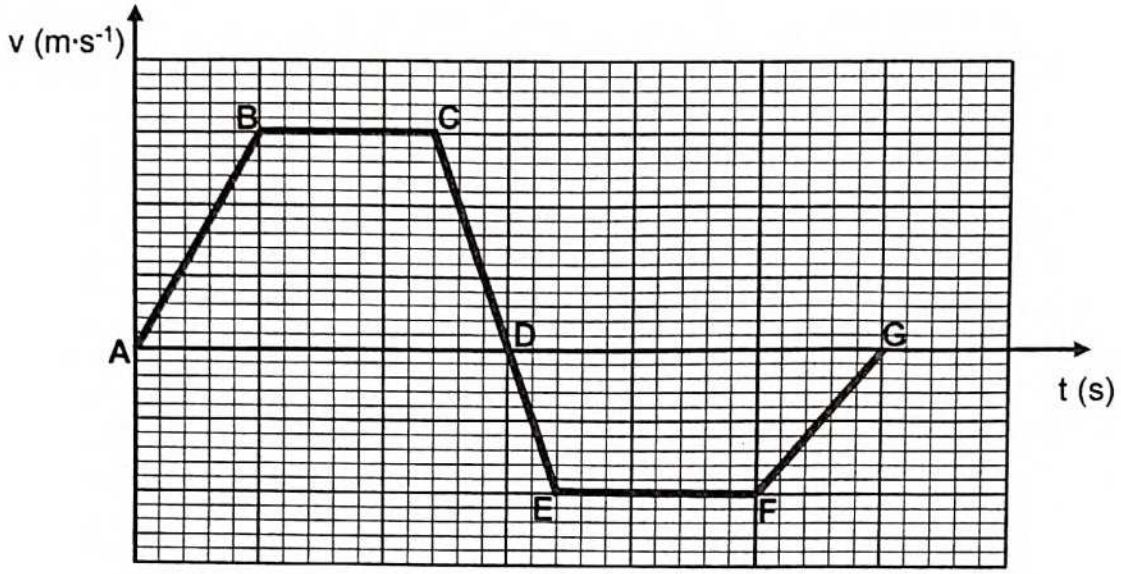
Which graph correctly shows the number of electrons emitted from the metal surface as the intensity of the light is increased?



[20]

QUESTION 2 KINEMATICS

2.1 A child runs in a straight line across a field, starting due East. After running some distance, she turns and runs back (in a straight line) towards her starting point. The graph below shows the velocity of the child against time.



2.1.1 At which point(s) is the child momentarily at rest? (2)

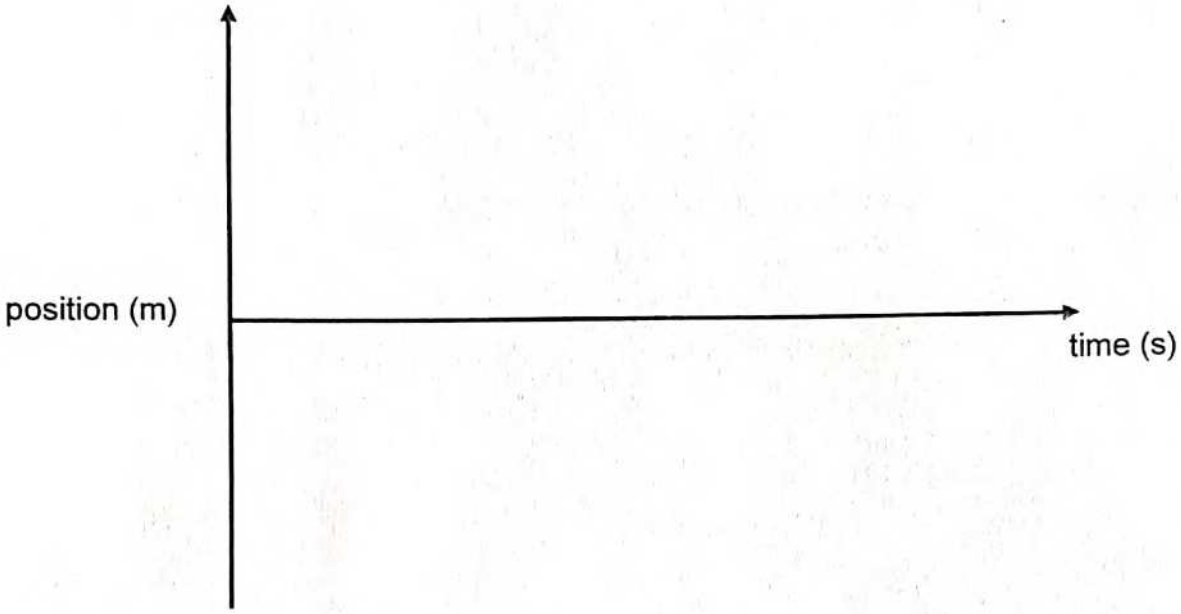
2.1.2 During which interval was the child's velocity greatest? (2)

2.1.3 During which interval(s) was the child running West? (2)

2.1.4 Define *acceleration*. (2)

2.1.5 During which interval was the magnitude of the child's acceleration greatest? (2)

2.1.6 Draw a sketch graph to show the child's change in position with time over the period shown. On your graph, label points A–G. (5)



2.2 A child and a puppy are running towards each other across a field.

The child runs at a constant velocity of 2,0 $m \cdot s^{-1}$ East. The puppy runs at a constant velocity of 2,5 $m \cdot s^{-1}$ West.

They are initially 100 m apart. How far will the child have run when the child and puppy meet? (5)

[20]

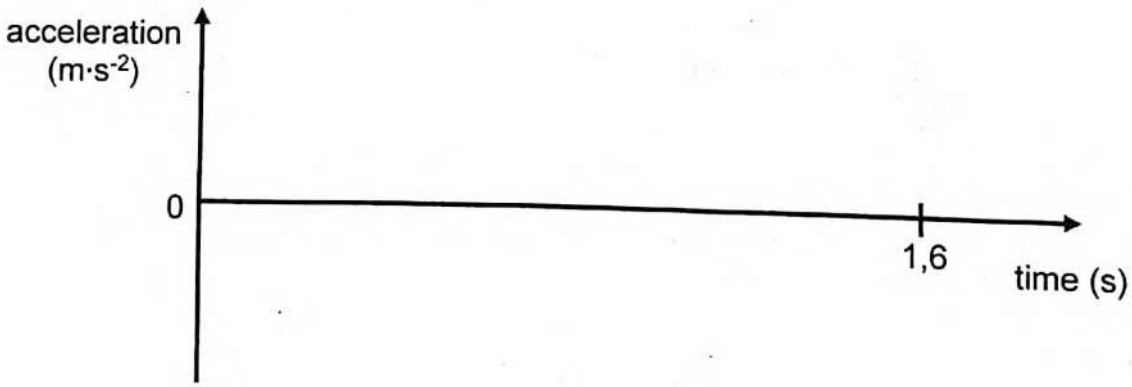
QUESTION 3 KINEMATICS

A small ball is thrown upwards into the air and caught when it returns to its original height, 1,6 seconds after it was thrown.

3.1 Calculate the magnitude of the initial velocity with which the ball was thrown upwards. (3)

3.2 What is the maximum height reached by the ball? (3)

3.3 On the axes provided, draw a graph to show the acceleration of the ball over the entire 1,6 second period described. (2)



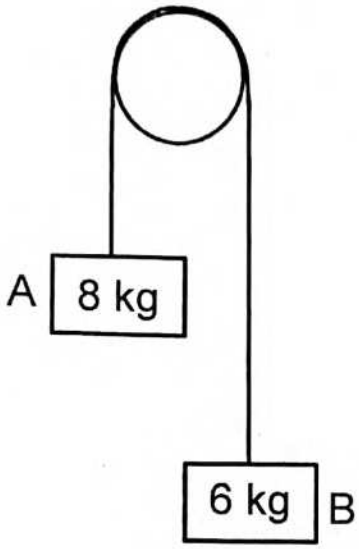
The ball is then thrown upwards a second time with an initial velocity of 5 $m \cdot s^{-1}$. This time the person does not catch the ball on its way down. It hits the ground 1,2 seconds after it was thrown.

3.4 What was the initial height of the ball above the ground when it was thrown? (3)

3.5 Calculate the magnitude of the velocity with which this ball hits the ground. (3)

QUESTION 4: NEWTON'S LAWS

Two blocks, A and B, are attached to the ends of an inextensible rope that passes over a pulley. The system is released from rest. The friction of the pulley and the mass of the rope are negligible.



4.1 Define *weight*. (2)

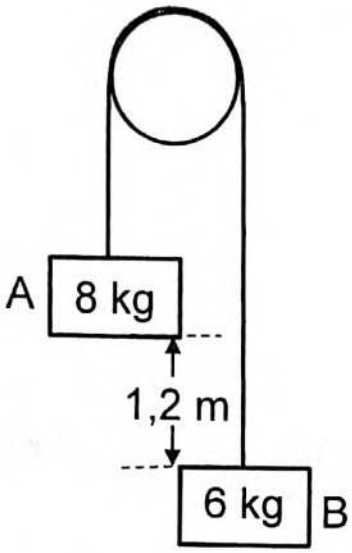
4.2 Draw a labelled free-body diagram of the forces acting on block B. (2)

4.3 State *Newton's second law*. (2)

4.4 Use Newton's second law to write an expression for F_{net} in terms of all the forces acting on block B. Do not substitute any values. (2)

4.5 Calculate the magnitude of the acceleration of the system **AND** the tension in the rope. (5)

Block A is 1,2 m above block B when the system is released from rest.

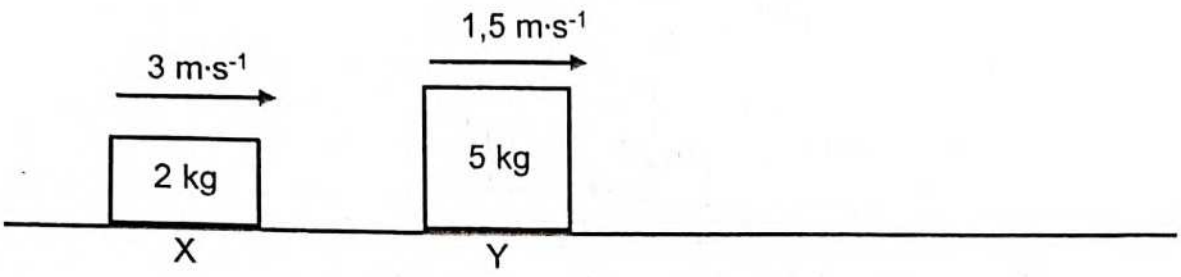


4.6 Calculate the time after release before the blocks bump into each other. (4)

[17]

QUESTION 5 MOMENTUM, WORK, ENERGY & POWER

Two blocks are travelling to the right along a frictionless surface. Block X has a mass of 2 kg and is travelling at 3 $m \cdot s^{-1}$. Block Y has a mass of 5 kg and is travelling at 1,5 $m \cdot s^{-1}$. The blocks collide and block Y continues in its original direction with a speed of **2,5 $m \cdot s^{-1}$** after their collision.



5.1 Determine the velocity of block X after the collision. (4)

5.2 Explain which block, if either, experiences the greater force during the collision. (2)

5.3 Explain which block, if either, experiences the greater change in momentum during the collision. (2)

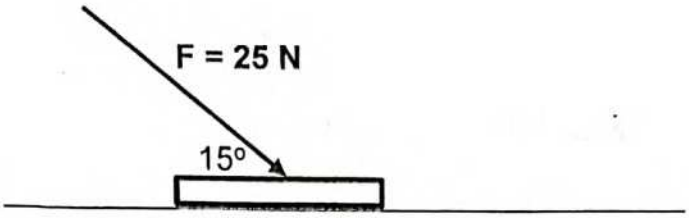
5.4 Define *impulse*. (2)

5.5 Consider block Y moving after the collision. Calculate the magnitude of the force that would be required to stop it over a period of 0,2 seconds. (3)

[13]

QUESTION 6 MOMENTUM, WORK, ENERGY & POWER

A coin (mass 10 g) is pushed across a table with a constant force of 25 N. This force is applied at an angle of 15° to the coin, as shown in the diagram below. The coefficient of kinetic friction between the coin and the table top is 0,6.



6.1 Draw a labelled free-body diagram showing the forces acting on the coin while it is being pushed. (4)

6.2 Determine the magnitude of the vertical component of the force that is applied to the coin. (2)

6.3 Define *normal force*. (2)

6.4 Determine the magnitude of the normal force acting on the coin. (4)

6.5 Calculate the magnitude of the frictional force acting on the coin while it is sliding. (3)

6.6 Determine the net force acting on the coin. (4)

6.7 State the *work-energy theorem*. (2)

6.8 Calculate the gain in kinetic energy of the coin if it is pushed with this steady force over a distance of 20 cm. (3)

6.9 How much energy is used to overcome friction as the coin is pushed over this distance of 20 cm? (3)

[27]

QUESTION 7: FIELDS

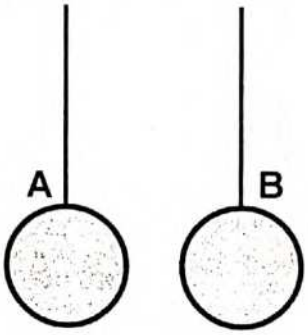
7.1 A satellite with a mass of 360 kg is in orbit around the Earth. The Earth has a mass of $6,0 \times 10^{24}$ kg and has a radius of $6,4 \times 10^{6}$ m. At a particular point in its orbit, the satellite experiences a force of 3,6 N towards the centre of the Earth.

7.1.1 State *Newton's law of universal gravitation*. (2)

7.1.2 At what height above the surface of the Earth does the satellite experience this force? (5)

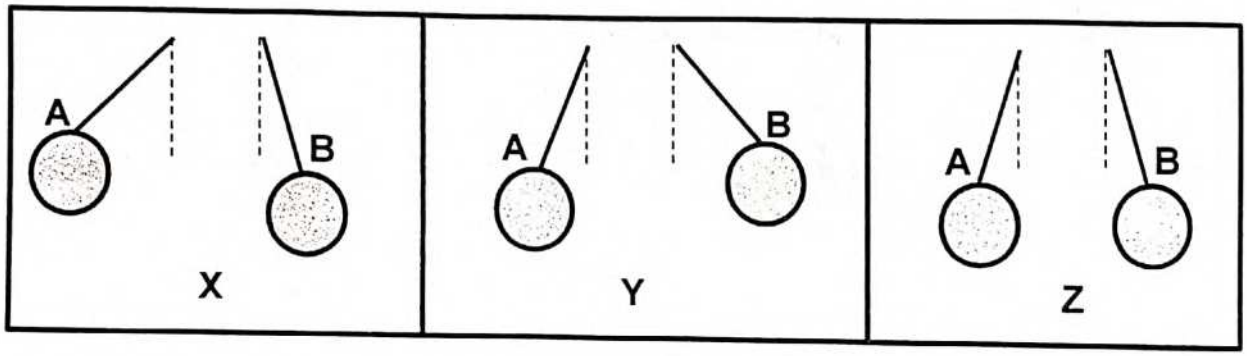
7.1.3 What is the magnitude of the gravitational acceleration at this point in the satellite's orbit? (3)

7.2 Two identical, uncharged, light metal spheres, A and B, are suspended from non-conducting strings, as shown.



They are then charged so that A carries a charge of + 2 μC and B carries a charge of + 6 μC. The spheres are in equilibrium at a distance of 5 cm apart.

Questions 7.2.1 and 7.2.2 refer to these diagrams:



7.2.1 Once the spheres are charged, which diagram would best represent the position of the spheres? Write down only **X**, **Y** or **Z**. (2)

7.2.2 If the mass of A was significantly greater than the mass of B, which of the three diagrams above would represent the positions of spheres A and B? Write down only **X**, **Y** or **Z**. (2)

7.2.3 Calculate the magnitude of the electrostatic force between the two charges. (4)

The identical spheres A and B are brought together to touch and then move apart again.

7.2.4 What charge will each sphere carry after the charges have touched and separated again? (2)

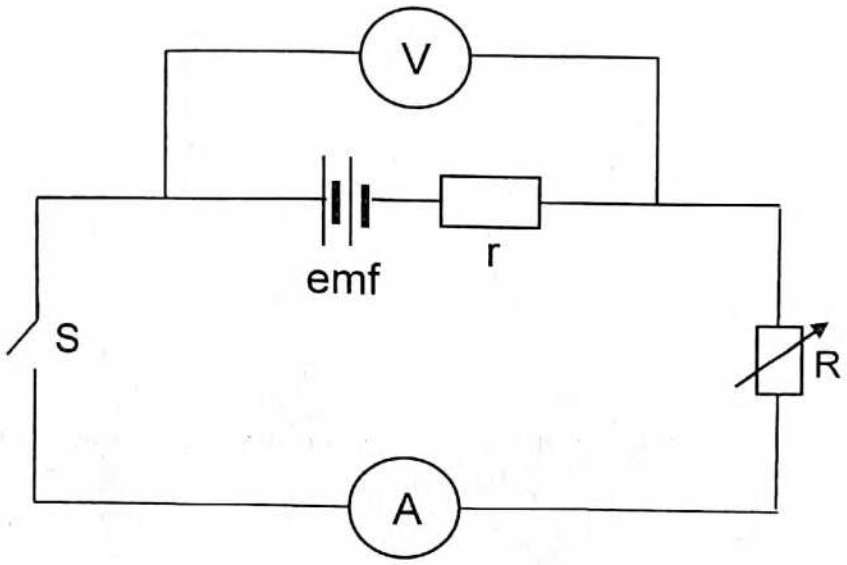
7.2.5 How many electrons are transferred during the contact of the two spheres? (2)

7.2.6 In which direction are the electrons transferred (**A to B** or **B to A**)? (2)

[24]

QUESTION 8 ELECTRIC CIRCUITS

8.1 The circuit below is connected to a battery of unknown *emf* and unknown internal resistance, *r*.

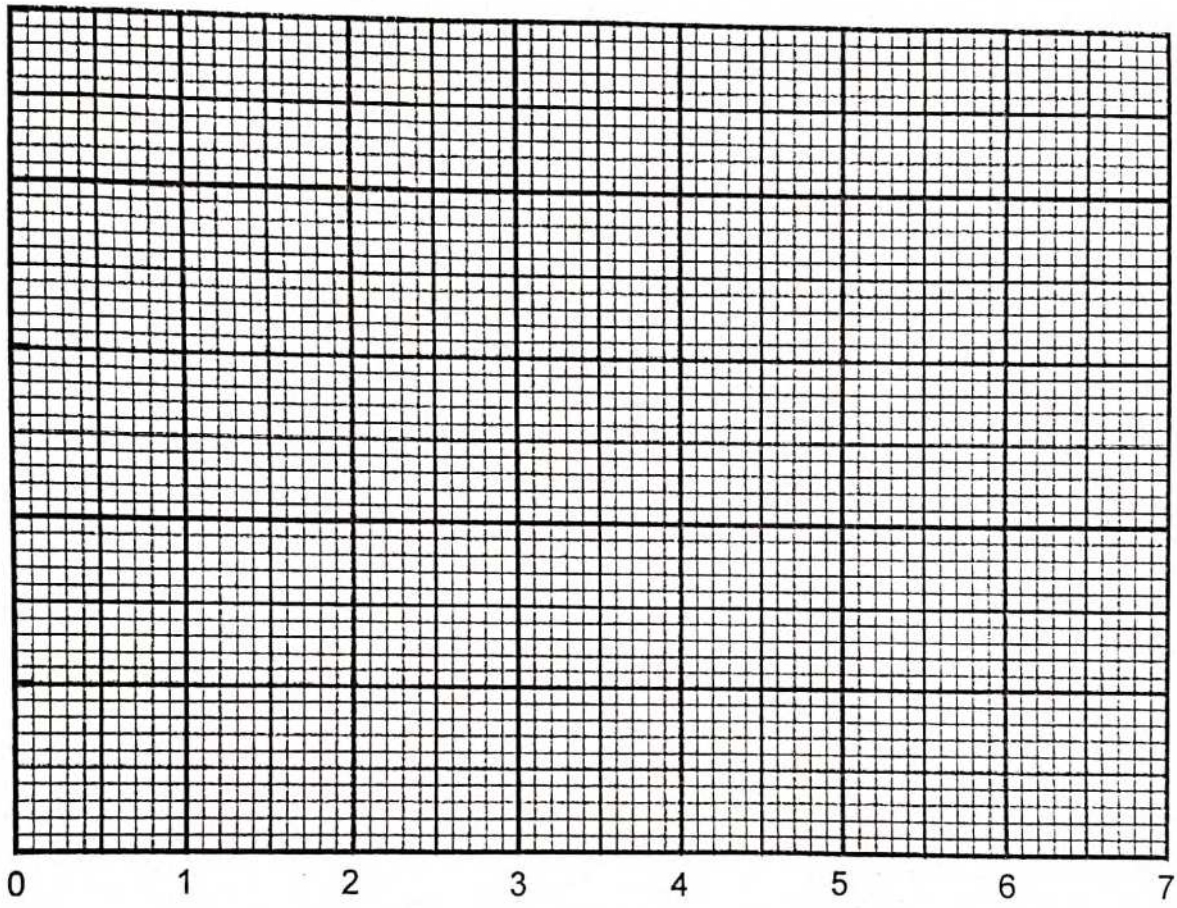


A student varies the current through the circuit by varying the external resistance, *R*, in the circuit, when switch S is closed. They measure the current in the circuit and record the reading on the voltmeter across the battery and these readings are recorded in the table below:

Current (A)	Reading on voltmeter (V)
0,8	18,7
2,4	15,8
3,2	14,1
4,4	12,6
5,5	10,3
6,3	9,0

8.1.1 Plot a graph of the reading on the voltmeter (on *y*-axis) vs the current (on *x*-axis) on the graph paper below.

(Spare graph paper is printed on page 31, should you need it.) (6)



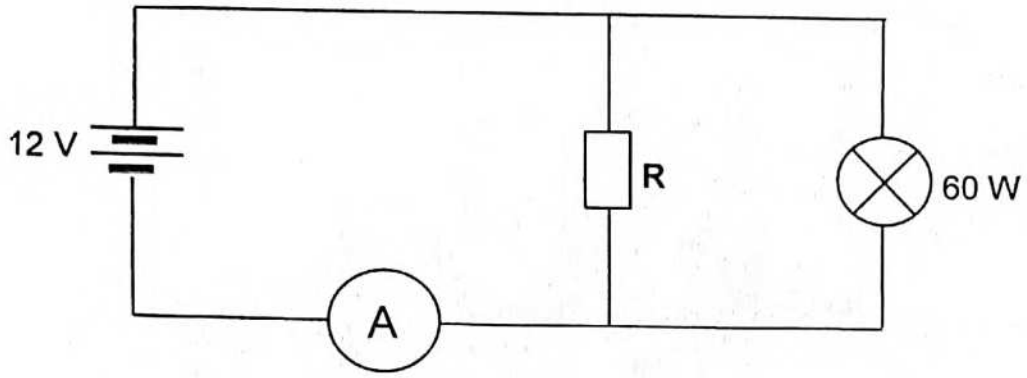
8.1.2 Calculate the gradient of the graph. Show the values that you used on your graph and include the appropriate unit in your answer. (4)

8.1.3 Use an appropriate equation and your answer to Question 8.1.2 to calculate the internal resistance of the given cell. (3)

8.1.4 Without a calculation, determine the *emf* of the battery used in this investigation. Briefly explain how you obtained this value. (2)

8.1.5 What will the value of R be when the current flowing in the circuit is 4,0 A? (3)

8:2 The circuit below shows a resistor, R, and a bulb connected to a 12 V battery with negligible internal resistance. The ammeter reads 6 A and the power rating of the bulb is 60 W.



8.2.1 Calculate the resistance of the bulb. (3)

8.2.2 State *Ohm's law*. (2)

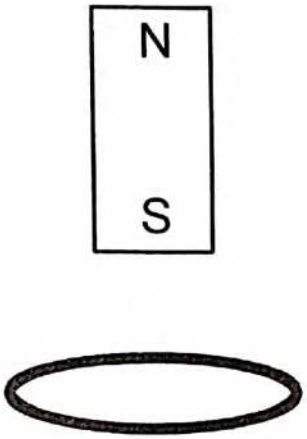
8.2.3 Calculate the resistance of the resistor, **R**. (4)

8.2.4 How much energy will be used by the resistor, **R**, in 2 minutes? (3)

[30]

QUESTION 9 ELECTRODYNAMICS

9.1 A metal ring lies on a table. The south pole of a permanent magnet moves vertically downwards towards the metal ring from above.



9.1.1 **On the diagram above**, draw the magnetic field lines around the permanent magnet shown. (3)

9.1.2 State *Lenz's law*. (2)

9.1.3 When viewed from above, does current flow clockwise or anticlockwise in the metal ring? (2)

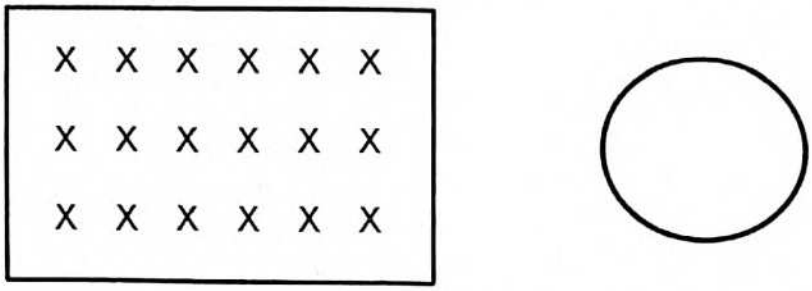
9.1.4 Explain why current flows in the metal ring. (3)

9.1.5 Suggest one way in which the current induced in this metal ring could be increased for this magnet. (2)

9.1.6 Define *magnetic flux linkage*. (2)

9.1.7 Explain how the induced current would change if the metal ring was replaced by a coil. (2)

9.2 You have a uniform magnetic field (as shown) and a loop of wire.



9.2.1 In relation to your page, what is the direction of the uniform magnetic field shown? (2)

9.2.2 Describe two ways in which you could generate a current in the wire loop using the uniform magnetic field shown. *You are encouraged to answer this question using bulleted points.* (2)

[20]

QUESTION 10 PHOTONS AND ELECTRONS

UV radiation with a frequency of 15×10^{14} Hz is shone on to a zinc disc. Electrons leave the surface of the zinc disc. The work function of zinc is 4,3 eV.

10.1 Why do electrons leave the surface of the zinc disc? (2)

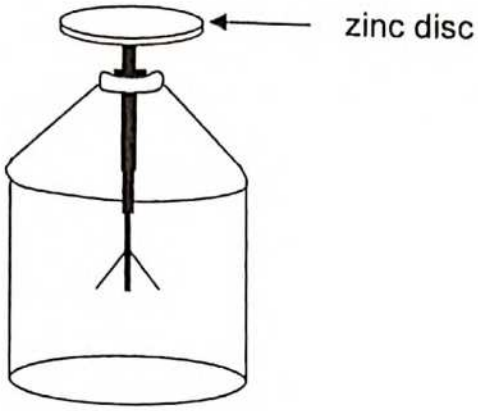
10.2 Define *work function*. (2)

10.3 Convert the work function of zinc to joules. (2)

10.4 Calculate the maximum kinetic energy of the electrons ejected from the zinc disc when this UV light is shone on it. (3)

10.5 Calculate the maximum velocity of the ejected electrons. (4)

The zinc disc is placed on top of an electroscope and the same UV light is once again shone on the disc. The leaves of the electroscope lift up.



10.6 Briefly explain why the leaves of the electroscope lift up when UV light is shone on the zinc disc. (2)

[15]

Total: 200 marks