assessment matters

NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2016

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 12 pages, an Answer Sheet of 1 page and a Data Sheet of 2 pages (i–ii). Please make sure that your question paper is complete.

2. Answer ALL the questions.

3. Read the questions carefully.

4. Question 1 consists of 10 multiple-choice questions. There is only one correct answer to each question. The questions are answered on the multiple-choice Answer Sheet provided on the inside cover of your Answer Book. The letter that corresponds with your choice of the correct answer must be marked with a cross as shown in the example below:

A	**B**	~~**C**~~	**D**	Here the answer C has been marked.

5. Use the data and formulae whenever necessary.

6. Start each question on a new page.

7. You may use an approved, non-programmable and non-graphical calculator, unless otherwise stated.

8. Show your working in all calculations.

9. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.

10. Where appropriate, express answers to TWO decimal places.

11. It is in your own interest to write legibly and to present your work neatly.

QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice Answer Sheet on the inside front cover of your Answer Book. Make a cross (X) in the box corresponding to the letter that you consider to be correct.

1.1 Which set of physical quantities consists only of scalar quantities?

A Velocity, speed and time.
B Displacement, velocity and acceleration.
C Time, distance and speed.
D Acceleration, speed and distance.

1.2 A car is travelling west at 12 m·s^{-1} when the driver notices a stop sign. The driver applies brakes, and the car stops at the stop sign. Which is the best description of the velocity and acceleration of the car while it is slowing down?

	Velocity (m·s^{-1})	**Acceleration (m·s^{-2})**
A	East	East
B	West	East
C	East	West
D	West	West

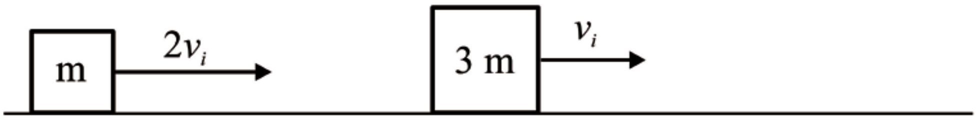
1.3 A small aeroplane starting from rest can achieve a high enough speed to take off from a runway that is 400 m long. Another, heavily loaded aeroplane, also starting from rest, has the same acceleration but needs to achieve twice the speed to take off. What is the minimum length of runway that will be needed for the heavy plane to take off?

A 400 m
B 800 m
C 1 200 m
D 1 600 m

1.4 A block is suspended by a single, vertical string from the ceiling. Which force forms a 'Newton's third law pair' with the weight of the block?

A The gravitational force exerted by the block on the Earth.
B The force from the ceiling acting on the block.
C The weight of the block has no 'Newton's third law pair' as the block is in equilibrium.
D The force of tension in the string acting on the block.

1.5 The diagram below shows two blocks sliding on a frictionless surface. The smaller block is travelling faster; it catches up and collides with the bigger block.



The two blocks stick together. What is the speed of the two blocks after the collision?

A $\frac{v_i}{2}$

B $\frac{4v_i}{5}$

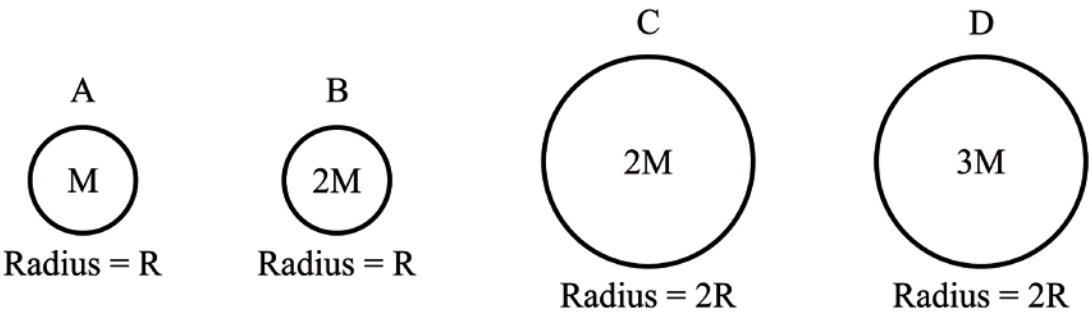
C v_i

D $\frac{5v_i}{4}$

1.6 A roller coaster starts from rest and rolls down a frictionless track, reaching speed v at the bottom of the track. If you want the roller coaster to have a speed $2v$ at the bottom of the track, what must you do to the track?

A Make the track 2 times higher.
B Keep the height the same, but make the track twice as steep.
C Make the track 4 times higher.
D Make the track $\sqrt{2}$ times higher.

1.7 Which one of the planets depicted will have the greatest free-fall acceleration on the surface of the planet?

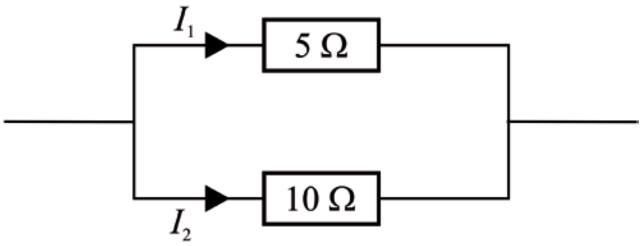


1.8 Two charges of equal magnitude are placed as shown in the diagrams below. In which diagram does the resultant electric field at the dot have the largest magnitude?

A ⊕ • ⊝   B ⊕ • ⊕

C ⊕ ⊝ •   D ⊝ ⊝ •

1.9 5 Ω and 10 Ω resistors are connected in parallel as shown in the diagram.



The relationship between current I_1 and current I_2 can be expressed as:

A $I_2 = I_1$.

B $I_2 = \frac{5}{10} I_1$.

C $I_2 = \frac{5}{15} I_1$.

D $I_2 = \frac{15}{10} I_1$.

1.10 A metal ring lies on a table. When the south pole of a magnet moves down towards the ring, a current is induced. When viewed from above, the direction of the induced current is:

A clockwise because the flux is increasing.
B clockwise because the flux is decreasing.
C anticlockwise because the flux is increasing.
D anticlockwise because the flux is decreasing.

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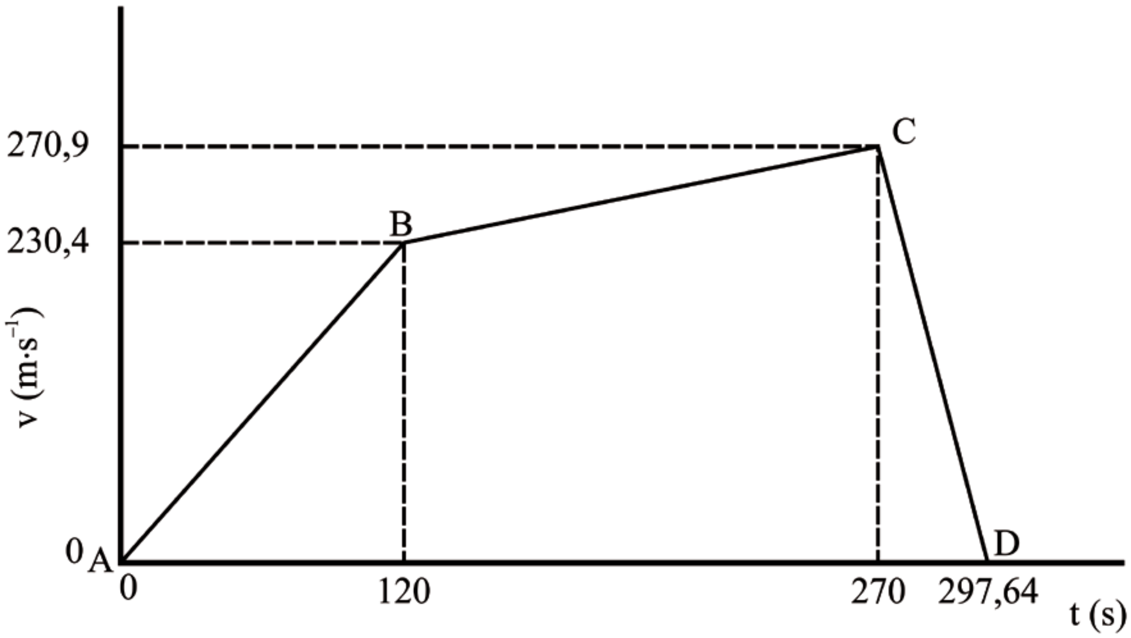
QUESTION 2 KINEMATICS

An experimental rocket, designed to land upright, was tested recently.

During liftoff, the following velocity-time graph was recorded.



2.1 Define *acceleration*. (2)

2.2 Calculate the acceleration of the rocket during the first stage (from A to B). (4)

The rocket then fired a second stage (from B to C) before turning off at 270 s.

2.3 Describe the rocket's **velocity** and **acceleration** from C to D. Directions must be included. (4)

2.4 At what time did the rocket reach its maximum height of 55 165,34 m? (2)

The rocket then fell freely from rest from the height of 55 165,34 m. At a height of 6 000 m, the rocket engines fire and provide a constant acceleration until the rocket reaches the ground at a speed of 1 $m \cdot s^{-1}$.

2.5 Define *speed*. (2)

2.6 Calculate the magnitude of the rocket's velocity at a height of 6 000 m. (3)

2.7 Calculate the magnitude of the rocket's acceleration during the last 6 000 m. (3)

The rocket has a mass of 5 800 kg.

2.8 Draw a labelled free-body diagram of the rocket during the last 6 000 m. The relative sizes of the forces must be clear. (2)

2.9 Calculate the thrust exerted on the rocket during the last 6 000 m. (5)

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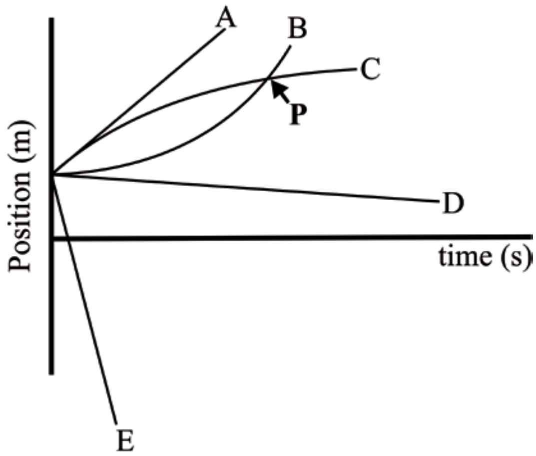
QUESTION 3 KINEMATICS

3.1 Five children (A, B, C, D and E) are playing in the street outside their homes. The street runs in an east–west direction. The positions of the children are plotted on the position vs time graph below. Define **east as positive**.



Use the graph to answer the questions that follow. Use only the correct letter(s) in your answer.

3.1.1 Which of the children are running west? (2)

3.1.2 Which of the children are running at a constant velocity? (3)

3.1.3 Which of the children are slowing down? (1)

3.1.4 Which of the children has the highest average speed? (1)

3.1.5 Describe what happened at point labelled **P** on the graph. (2)

3.2 A puppy is running at a constant speed of 2 $m \cdot s^{-1}$ towards a mud puddle that is a distance of 6 m away.

3.2.1 Define *distance*. (2)

3.2.2 How long does the puppy take to get to the mud puddle? (3)

Lauren is 10 m behind the puppy and is running at a constant speed of 4 $m \cdot s^{-1}$ chasing the puppy.

3.2.3 How far does Lauren run in the time it takes the puppy to get to the mud puddle? (2)

3.2.4 How far is Lauren from the mud puddle when the puppy reaches the mud puddle? (2)

Lauren doesn't want the puppy to get dirty. Her initial speed is 4 $m \cdot s^{-1}$ and she accelerates uniformly to ensure she catches the puppy at the instant just before it reaches the mud puddle.

3.2.5 Calculate the magnitude of Lauren's acceleration. (3)

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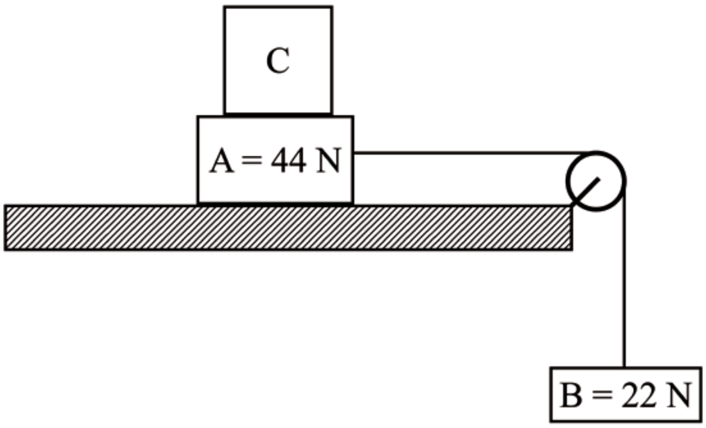
QUESTION 4 NEWTON'S LAWS

Block A has a weight of 44 N and Block B has a weight of 22 N. Block A is placed on a rough table that has a coefficient of static friction of 0,2. Block A and Block B are connected via a light, inextensible rope over a frictionless pulley and Block C is placed on top of Block A as shown in the diagram below.



The system, as shown in the diagram, is only just at rest and on the limit of sliding.

4.1 Determine the tension in the rope joining Block A and Block B while the system is at rest. (2)

4.2 Define *frictional force due to a surface*. (2)

4.3 State the magnitude of the frictional force required for Block A to be at rest. (2)

4.4 Calculate the minimum weight of Block C to stop Block A from sliding. (5)

Block C is removed and the system starts accelerating.

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

4.6 Draw a labelled, free-body diagram for Block B while it is accelerating. (2)

The magnitude of the acceleration of the system is 2,3 $m \cdot s^{-2}$.

4.7 Calculate the tension in the rope joining the blocks. (4)

4.8 Calculate the frictional force acting on Block A while it is accelerating. (3)

4.9 State two reasons why the frictional force between Block A and the surface is smaller than the value stated in Question 4.3. Briefly explain your answer. (4)

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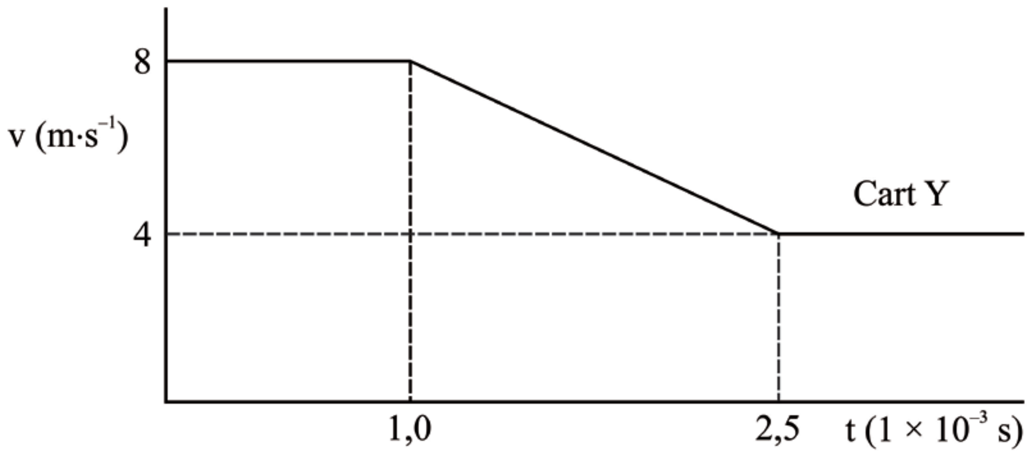
QUESTION 5 MOMENTUM, WORK, ENERGY AND POWER

5.1 A student is experimenting with two carts on a frictionless surface. Cart X has a mass of 0,5 kg and is initially at rest. Cart Y has a mass of 1,2 kg and collides with cart X. Cart Y is initially travelling at 8 m·s^{-1} **east** and travels at 4 m·s^{-1} east after colliding with cart X. The velocity of cart Y is represented on the velocity time graph below.



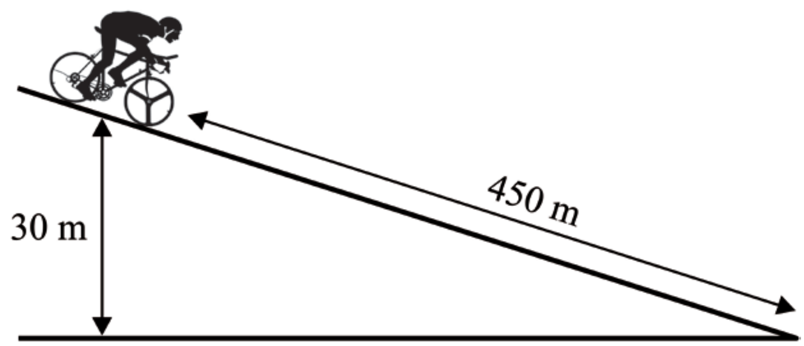
5.1.1 State the *law of conservation of momentum*. (2)

5.1.2 Calculate the magnitude of the final velocity of cart X. (4)

5.1.3 Calculate the change in momentum of cart Y. (4)

5.1.4 Calculate the magnitude of the force that cart X exerts on cart Y. (4)

5.2 A cyclist is travelling at 15 m·s^{-1} at the top of a 450 m long slope that is 30 m high. The cyclist and her bicycle have a combined mass of 70 kg. A constant frictional force of 12 N acts on her all the way to the bottom of the slope.



5.2.1 Calculate the kinetic energy of the cyclist at the top of the slope. (3)

5.2.2 Calculate the gravitational potential energy of the cyclist at the top of the slope. (3)

5.2.3 Calculate the work done by the frictional force. (3)

5.2.4 Calculate the cyclist's speed at the bottom of the slope. (4)

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QUESTION 6 FIELDS

David is curious as to how the electric field at a fixed distance away from a charged sphere depends on the magnitude of the charge on the sphere.

David charges the sphere positively and measures the electric field (E) at a fixed distance from the centre of the sphere. During his investigation, he repeats the experiment, each time changing the magnitude of the charge on the sphere (Q). The results are recorded in the table below.

Q (nC)	**E ($kN \cdot C^{-1}$)**
2	6
5	19
7	25
9	34
12	41
14	52

6.1 Define *electric field*. (2)

6.2 Draw the electric field lines around a positively charged sphere. (2)

6.3 State an hypothesis for this investigation. (2)

6.4 Plot a graph of electric field (on the y-axis) vs charge (on the x-axis) on the graph paper provided in the **Answer Sheet**. (6)

6.5 Calculate the gradient of the graph. Indicate the values you used for this calculation on your graph. (4)

6.6 Use your answer from Question 6.5, your knowledge of electric fields and that the equation $y = mx + c$ describes a straight line to determine the distance from the charge at which David made all the measurements of electric field.

Express your answer to three decimal places. (3)

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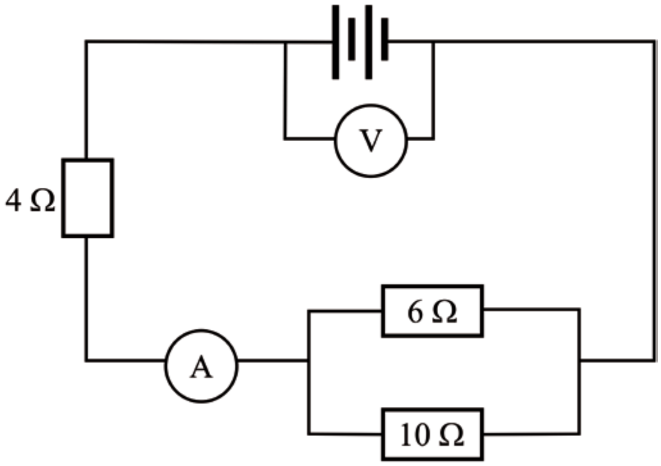
QUESTION 7 ELECTRIC CIRCUITS

7.1 A circuit that consists of a battery with an emf of **26 V** and an unknown internal resistance, three resistors, an ammeter and a voltmeter is set up as shown in the diagram below.



7.1.1 Define *resistance*. (2)

7.1.2 Calculate the effective resistance of the circuit. (5)

The ammeter measures a current of **3 A** with the circuit connected as shown.

7.1.3 Define *current*. (2)

7.1.4 Calculate the potential difference that will be recorded by the voltmeter. (3)

7.1.5 Hence, determine the internal resistance of the battery. (3)

Sometimes, resistors burn out while in operation.

7.1.6 Describe what would happen to the reading on the voltmeter if the 6 Ω resistor burnt out. Use a suitable equation in your explanation. (4)

7.1.7 Predict what the reading on the voltmeter would be if the 4 Ω resistor burnt out. Briefly explain your answer. (3)

7.2 Chris finds an unlabelled battery in the lab and needs to use it in a circuit. However, it is necessary to determine the emf and the internal resistance to decide if the battery is suitable.

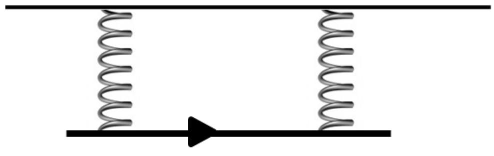
Chris connects the unlabelled battery to a 2,0 Ω resistor and measures a current of 2,0 A through the resistor. He then connects the battery to a 1,0 Ω resistor and measures a current of 3,0 A.

Calculate the emf and internal resistance of the unlabelled battery. (5)

[27]

QUESTION 8 ELECTRODYNAMICS

8.1 A conductor is hanging from the ceiling on two springs in an external magnetic field. The springs and the conductor are shown in the diagram.

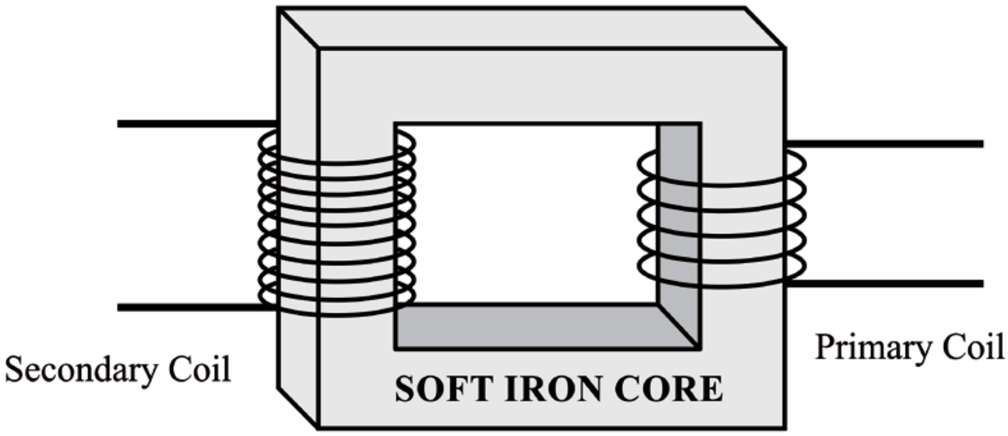


A conventional current is directed from left to right through the conductor.

8.1.1 In which direction must an external magnetic field be directed to increase the tension in the springs supporting the conductor? (2)

8.1.2 Name two factors you could adjust to increase the tension in the springs. (2)

8.2 An iron-core transformer is illustrated below.



[Source: <http://www.school-for-champions.com/science/images/ac_transformers_simple.gif>]

8.2.1 State *Faraday's Law of electromagnetic induction*. (2)

8.2.2 Explain the operation of an iron-core transformer. Use bullet points in your answer. (4)

Eskom produces electricity at a power station with a potential difference of 20 kV. This electricity is transmitted via a network of cables across the country at a potential difference of 765 kV.

8.2.3 Why does Eskom transmit energy at such a high voltage? Use a suitable equation to help you explain your answer. (4)

8.2.4 Calculate the ratio of the number of turns on the secondary coil to the number of turns on the primary coil needed to change 20 kV to 765 kV (3)

8.2.5 Name the type of transformer used to change 20 kV to 765 kV. (2)

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QUESTION 9 PHOTONS AND ELECTRONS

The work functions of selected metals are recorded in the table below.

Metal	**Work Function ($\times 10^{-19}$ J)**
Sodium	3,94
Aluminium	6,53
Zinc	6,90
Iron	7,20

9.1 Define *work function*. (2)

Light of wavelength 296 nm is incident on a sample of each metal in turn.

9.2 Calculate the energy of a photon of light of 296 nm. (3)

9.3 Which metals listed in the table will emit electrons at this wavelength? (2)

9.4 Calculate the maximum kinetic energy of the electrons ejected from sodium metal when light of 296 nm is incident on the metal. (3)

9.5 The intensity of the 296 nm light is now increased. Will the light now be able to eject electrons from the other metals listed in the table? Briefly explain your answer. (4)

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Total: 200 marks