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St Andrew's College & Diocesan School for Girls

ST ANDREW'S COLLEGE

THE DIOCESAN SCHOOL
FOR GIRLS**GRADE 12****PHYSICAL SCIENCES: PAPER 1 (PHYSICS)**Date: Monday 7 September 2020
Time: 08h00Examiner: Mrs K Cobbing
Moderator: Mrs E Goodier

Duration: 3 hours

200 marks

READ THE FOLLOWING INSTRUCTIONS CAREFULLY:

1. Write your name on the front cover of all answer booklets that you use and on your question paper.
2. Please check that your paper is complete:
 - This question paper has TWELVE pages, including this coversheet.
 - There should be a loose, double-sided **data sheet** provided on coloured paper as an insert in this question paper.
 - You are to write all your answers in the answer booklet provided, completing Question 1 on the grid provided on the insert and question 2.2.2 on the graph axes provided on the insert.
3. Please hand in your question paper as well as your answer booklet.
4. Read the questions carefully.
5. Present your work neatly and legibly.
6. Answer ALL the questions.
7. You may answer the questions in any order, but you are to start each question on a new page.
8. Number your answers exactly as the questions are numbered.
9. All working must be shown and units must be given with answers.

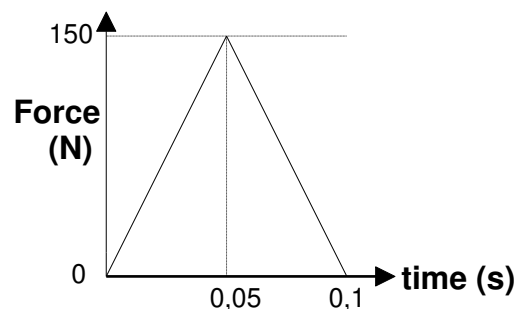
QUESTION 1 MULTIPLE CHOICE QUESTIONS

On your ANSWER SHEET indicate with a cross (X) the letter that corresponds to the correct answer for each of these questions. 10 x (2) marks

- 1.1 Linear momentum is defined as *the product of the mass and velocity of the object* ($p = mv$). This consists of:
- A. one vector quantity and two scalar quantities
 - B. two vector quantities and one scalar quantity
 - C. three vector quantities
 - D. three scalar quantities
- 1.2 Which of the following is **true** of the motion of an object that falls from rest in the absence of air friction?
- A. Its displacement is directly proportional to the time for which it falls.
 - B. Its velocity is directly proportional to the time for which it falls.
 - C. Its acceleration is directly proportional to the time for which it falls.
 - D. Its displacement is directly proportional to its velocity while it falls.
- 1.3 Which one of the following is **not** a valid example of the pair of forces that apply to Newton's Third Law of Motion?
- A. The book pushing down on a table and the force of the table pushing upwards on the book.
 - B. The forces of repulsion experienced by two magnetic north poles.
 - C. The forces of attraction that an electron and a proton in a hydrogen atom exert on each other.
 - D. The force of friction acting on a box and the force of a person pushing the box over a rough horizontal surface at constant velocity.
- 1.4 The graph alongside represents the change in force with time for a tennis ball as it strikes a wall.

The area under the graph would give the:

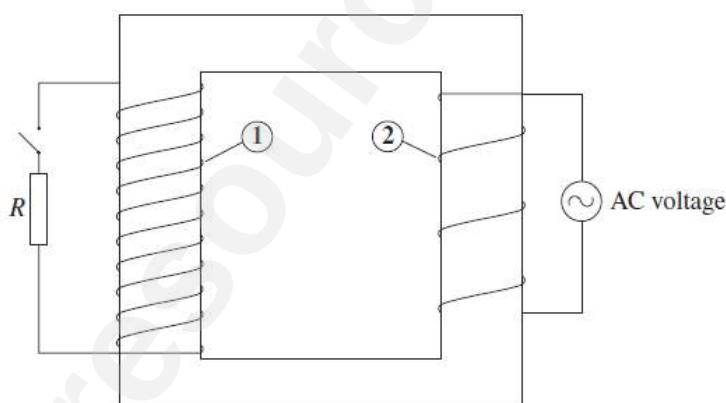
- A change in kinetic energy of the tennis ball
- B work done on the tennis ball
- C change in momentum of the tennis ball
- D power of the tennis ball



- 1.5 Gemma is lifting boxes of identical mass from the ground onto a bench. At first, it takes her 2s to lift each box. Later in the day it takes her 3s. Which of the following will be true when she lifts the boxes later in the day?
- A. Less work is done in lifting each box
 - B. More work is done in lifting each box
 - C. Smaller power is produced in lifting each box
 - D. Greater power is produced in lifting each box
- 1.6 A 10 kg mass is balanced on top of a 2 m high pole. How much work is done by the pole in supporting the mass?
- A. -196 J
 - B. 0 J
 - C. 98 J
 - D. 196 J

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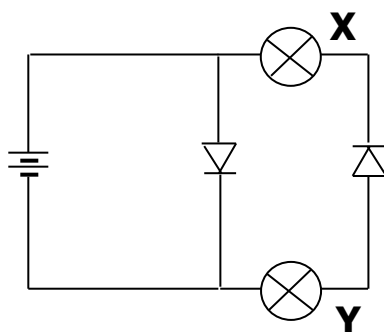
- 1.7 The diagram shows a model of a transformer in a circuit.



Which of the following correctly identifies Part 1 and Part 2 and the function of the transformer?

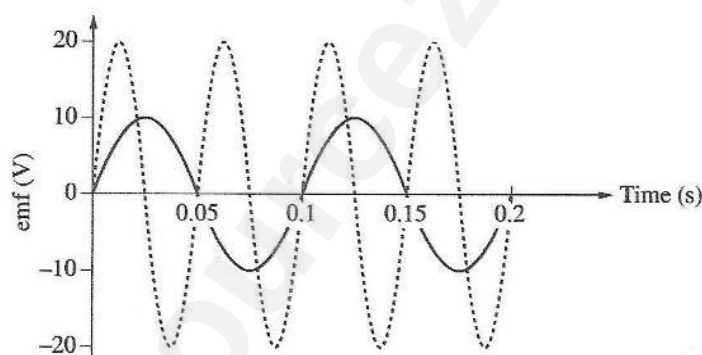
	Part 1	Part 2	Function
A	Primary coil	Secondary coil	Step-up
B	Secondary coil	Primary coil	Step-down
C	Primary coil	Secondary coil	Step-down
D	Secondary coil	Primary coil	Step-up

- 1.8 The accompanying circuit shows light bulbs and diodes connected to a battery.



Which light bulb will light up in the configuration shown?

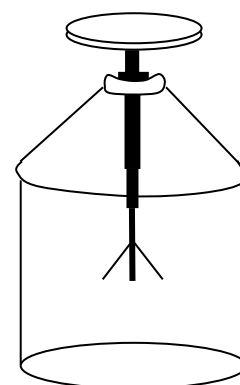
- A. Neither light bulb B. X C. Y D. Both light bulbs
- 1.9 In the graph shown, the solid curve shows how the emf produced by a simple generator varies with time. The dashed curve is the output from the same generator after a modification has been made to the generator.



Which modification was made to produce the result shown?

- A The area of the coil was doubled.
 B A split-ring commutator was added.
 C The speed of rotation of the coil was doubled.
 D The number of turns in the coil was quadrupled.
- 1.10 UV light is shone on zinc plate placed on the insulated electroscope shown alongside and the thin pieces of gold leaf in the electroscope are raised. The reason for this observation is that:

- A. The UV light provides positive charges to the electroscope
 B. The UV light provides negative charges to the electroscope
 C. The UV light removes positive charges from the electroscope
 D. The UV light removes negative charges from the electroscope

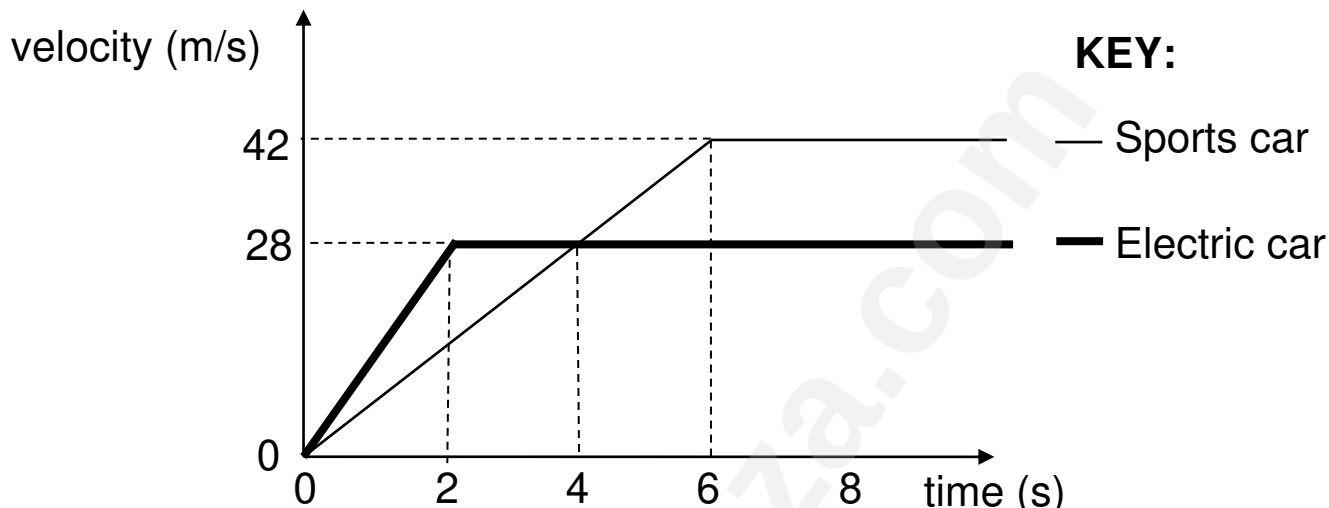


QUESTION 2

KINEMATICS

(START THIS QUESTION ON A NEW PAGE)

An electric car and a sports car travel **due South** on a straight road. The velocity of each car is shown against time in the graph below.



- 2.1.1 Define *acceleration*. (2)
- 2.1.2 Calculate the acceleration of the sports car. (4)
- 2.1.3 Describe what happens at 4 seconds. (1)
- 2.1.4 How far has the electric car travelled after 6 seconds? (3)
- 2.1.5 At what time (after the start) will the sports car be next to the electric car? (4)
- 2.1.6 A daredevil wants to cross the racetrack while the test is being conducted. The track is 12 m wide and the challenge is to walk across the track at $1,5 \text{ m}\cdot\text{s}^{-1}$. If the car is travelling at a constant velocity of 28 m/s, what is the minimum distance in front of the electric car that the person must start crossing the road, to do so safely? (4)

An engineer conducts a test on the electric car to establish a relationship between the time for which the car accelerated (Δt) and the velocity reached by the car (v). The engineer arranges a test where the electric car accelerates from rest for different time intervals and the velocity reached by the car is recorded. The results are shown below.

Δt (s)	v ($m.s^{-1}$)
0,5	4,2
0,8	6,4
1,2	9,5
1,5	12,2
2,0	16,1
2,4	19,0

- 2.2.1 State the independent variable in this investigation. (2)
- 2.2.2 Plot a graph of velocity reached by the car, v (on the y axis) vs the time for which the car accelerates, Δt (on the x-axis), on the graph paper provided **on the Answer Sheet**. (6)
- 2.2.3 Determine the gradient of your graph. Show the values you used on your graph and include the appropriate unit in your answer. (5)
- 2.2.4 Rearrange the equation $v = u + a\Delta t$ to write v in terms of Δt for the experiment described. (1)
- 2.2.5 Hence, use your answers to question 2.2.3 and Question 2.2.4 to calculate the acceleration of the car. (2)

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QUESTION 3 “FEARLESS FELIX”

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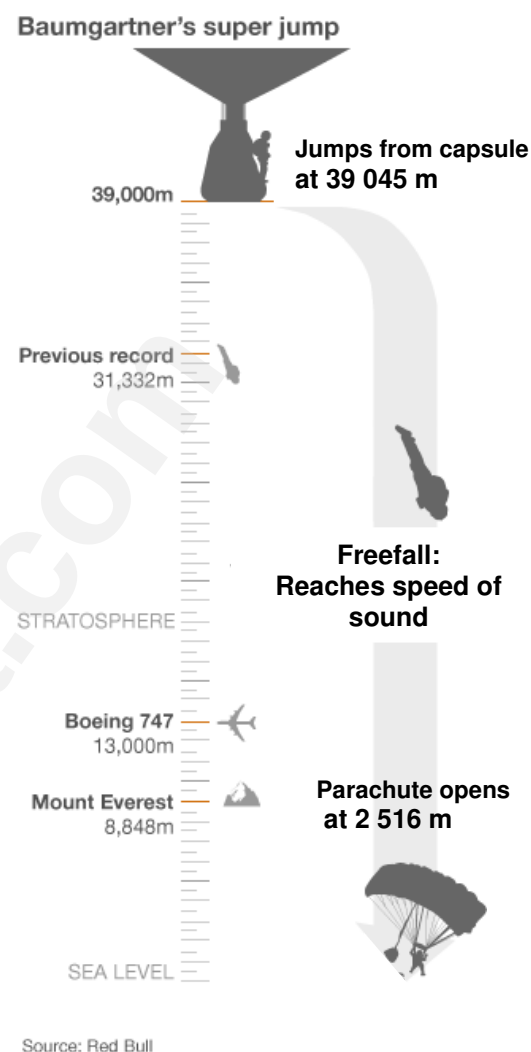
On 14 October 2012, Austrian-born Felix Baumgartner became the first skydiver to fall faster than the speed of sound when he jumped out of a stationary helium-filled balloon, at a height of 39 045 metres above the Earth's surface.

He reached an estimated top speed of 373 m/s, toppling Joseph Kittinger's record set in 1960.

Image of Baumgartner: <https://londonspeakerbureau.com/speaker-profile/felix-baumgartner/>
Image of jump adapted from Wikipedia

The diagram alongside shows this remarkable jump.

The value of g at this extreme altitude is $9,72 \text{ m.s}^{-2}$.



- 3.1 Define *velocity*. (2)
- 3.2 Use an equation of motion to calculate Baumgartner's average acceleration over his fall, assuming that he reached his top speed just before opening his parachute. Refer to the sketch alongside. (4)
- 3.3 Account for the difference between the value that you calculated in 3.2 and the value for g given above. (2)
- 3.4 Calculate the time for which Baumgartner was in free fall to reach his top speed. (3)

While Baumgartner was in free fall above the atmosphere, where air resistance is so small that it can be ignored, he let go of the camera he was holding.

- 3.5 What would happen to the camera? Explain your answer by referring to a law of physics. (3)

P.T.O.

When Baumgartner (mass 90 kg) opens his parachute, the parachute exerts a force of 2250 N upwards on him. At the height when he opens his parachute, the value of g is $9,8 \text{ m.s}^{-2}$.

- 3.6 State *Newton's second law*. (2)
- 3.7 Determine the magnitude of Baumgartner's acceleration as his parachute opens. (4)
- 3.8 Draw a labelled free body diagram to represent the forces acting on Baumgartner as he was falling vertically downwards at constant velocity, having opened his parachute. (3)
- 3.9 Sketch a graph for Baumgartner's acceleration while he was in the air. Known values should be shown, but no additional values need to be calculated. (4)

When Baumgartner lands on the ground, he experiences a force to bring him to rest from a velocity of 30 m.s^{-1} in 0,8 seconds.

- 3.10 Determine the magnitude of the force that Baumgartner experiences when he lands. (3)
- 3.11 When Baumgartner lands on the ground, he bends his knees. Explain the reason for this by referring to a physics principle. (3)

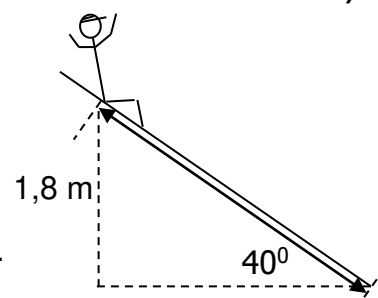
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QUESTION 4 MOMENTUM, WORK, ENERGY

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Annie (mass 30 kg) is sliding down a slide in the playground. The slide makes an angle of 40° to the ground.

The coefficient of dynamic friction between Annie and the slide is 0,4.



- 4.1.1 Draw a free body diagram showing the forces acting on Annie while she is sliding down the slide. (3)
- 4.1.2 Define the *normal force*. (2)
- 4.1.3 Determine the normal force acting on Annie. (3)
- 4.1.4 Calculate the magnitude of the frictional force between Annie and the slide as she slides down. (3)
- 4.1.5 Calculate Annie's acceleration. (5)
- 4.1.6 If Annie begins their slide at a vertical height of 1,8 m above the ground, how much work will be done by the frictional force as she slides down? (4)

4.1.7 Determine the speed of Annie at the bottom of the slide. (4)

At the bottom of the slide, Annie (mass 30 kg) collides with Billy (25 kg) who is stationary at the bottom of the slide. Billy travels at 3 m/s after the collision. Ignore any friction between the children and slide during the collision and immediately thereafter.

4.2.1 State the *principle of conservation of momentum*. (2)

4.2.2 Determine the velocity of the Annie after the collision. (4)

4.2.3 Which, if either, of the children will experience a greater **force** during the collision? Justify your answer (no calculations needed). (2)

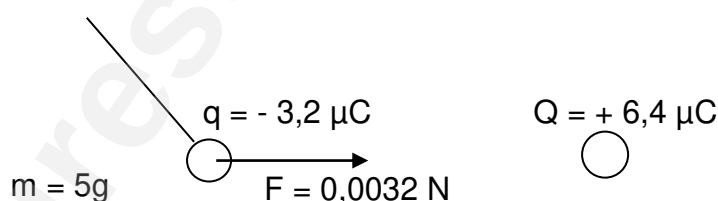
4.2.4 Which, if either, of the children will experience a greater **change in momentum** during the collision? Justify your answer (no calculations needed). (2)

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QUESTION 5 GRAVITATIONAL AND ELECTRIC FIELDS

(START THIS QUESTION ON A NEW PAGE)

A small spherical conductor with a mass of 5g and negative charge of $-3,2 \mu\text{C}$ is suspended by a light string which does not conduct charge. It is attracted to another fixed sphere carrying a charge of $+6,4 \mu\text{C}$ with a horizontal, electrostatic force of 0,0032 N.



5.1 Define *electric field strength*. (2)

5.2 Calculate the electric field strength at the point where the suspended conductor carrying the charge $q = -3,2 \mu\text{C}$ is. (3)

5.3 Which of the two charges, Q or q, is creating the field that you calculated in 5.2? (1)

5.4 State *Coulomb's law* in words. (2)

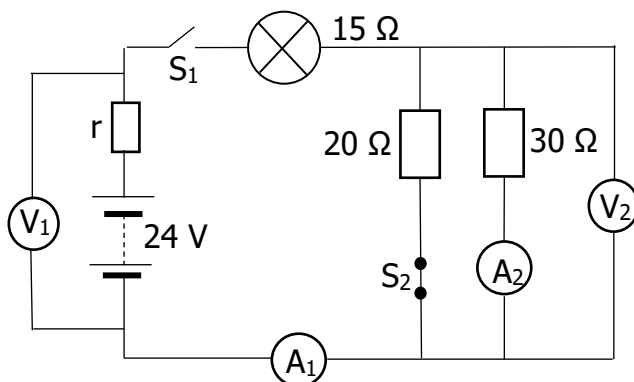
5.5 Calculate the distance between q and Q. (4)

5.6 Calculate the angle that the string makes with the vertical. (3)

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QUESTION 6**ELECTRIC CIRCUITS****(START THIS QUESTION ON A NEW PAGE)**

In the circuit below, the battery has an emf of 24 V and an unknown internal resistance. The resistances of the switch, ammeters and connecting wires are negligible. The voltmeters have very high resistance.



- 6.1 Define *emf*. (2)
- 6.2 When switch S_1 is open, what will be the reading on
- 6.2.1 A_1 ?
- 6.2.2 V_1 ?
- 6.2.3 V_2 ? (3)

Switch S_1 and S_2 are now closed. Voltmeter V_1 reads 21,6 V.

- 6.3 Define *resistance*. (2)
- 6.4 Determine the effective resistance of the parallel resistors. (2)
- 6.5 Find the reading on A_1 . (4)
- 6.6 Calculate the internal resistance of the battery. (3)
- 6.7 Determine the reading on A_2 . (3)
- 6.8 Calculate the rate of energy dissipation in the light bulb. (3)
- 6.9 If switch S_2 is opened, how will each of the following compare to just before the switch was opened? Write down only INCREASE, DECREASE, STAY THE SAME or BECOME ZERO.
- 6.9.1 Ammeter A_1
- 6.9.2 Voltmeter V_1
- 6.9.3 Voltmeter V_2
- 6.9.4 Ammeter A_2 (4)

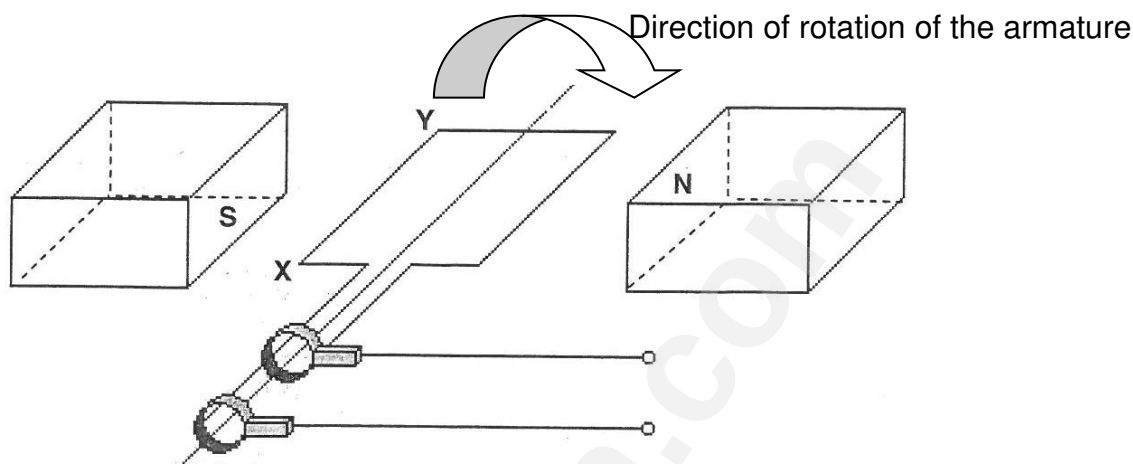
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QUESTION 7

ELECTRODYNAMICS

(START THIS QUESTION ON A NEW PAGE)

This simplified diagram represents an important component used to create electrical power for domestic and industrial use at any power station in South Africa.



- 7.1 Name the apparatus represented by the diagram. (1)
- 7.2 Give the energy change that takes place in this apparatus. (2)
- 7.3 State the direction of the current flow in the armature. Choose from X to Y or from Y to X. (1)
- 7.4 State *Faraday's Law of Electromagnetic Induction*. (2)
- 7.5 Draw a labelled graph of the resulting induced emf versus degrees of rotation for the above apparatus, when the armature turns a full 360° from its current horizontal position as shown. (3)
- 7.6 Briefly explain why you began your graph where you did in 7.5 for the position shown. (2)

The slip rings are replaced with a split ring commutator.

- 7.7 How will the current output change as a result of the split ring commutator? (1)
- 7.8 The apparatus shown in the diagram above is connected to a transformer at the power station.
- 7.8.1 Name the kind of transformer that would be used. (1)
- 7.8.2 Explain the advantage of connecting this apparatus to a transformer as described? (2)
- 7.9 In a cell phone charger, there are 1 600 turns on the primary coil and 50 turns on the secondary coil. If the charger operates on the mains supply of 240 V, what voltage is supplied to the cell phone battery? (4)

QUESTION 8**PHOTOELECTRIC EFFECT****(START THIS QUESTION ON A NEW PAGE)**

The Work Functions, in eV, of some elements are given below:

Element	Work Function (eV)	Element	Work Function (eV)
Aluminium	4,3	Lead	4,3
Beryllium	5,0	Silicon	1,1
Calcium	2,9	Silver	4,3
Copper	4,7	Sodium	2,3
Gold	5,1		

8.1 Define *work function*. (2)

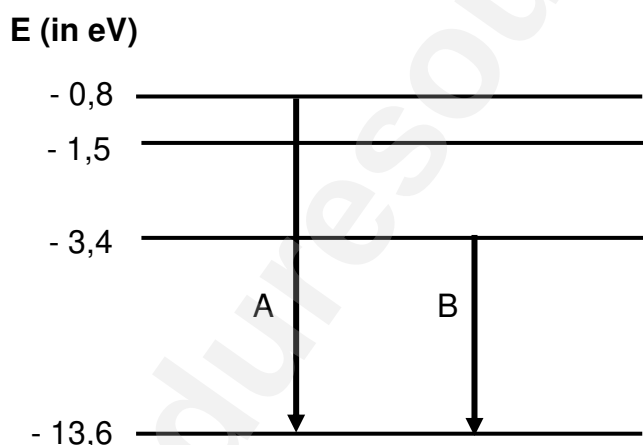
When light with a frequency of $5,8 \times 10^{15}$ Hz is shone on a metal surface, electrons are emitted with a maximum velocity of $2,6 \times 10^6$ m/s.

8.2 Determine the work function of this metal (in J). (5)

8.3 Looking at the table above, identify the metal that is being used. (3)

8.4 Which other metals, given in the table above, would NOT emit electrons under this light? (2)

The diagram below represents two electron transitions in an atom.



8.5 Without calculations, which transition will result in the shortest wavelength of light? Give a reason for your answer. (2)

8.6 Calculate the wavelength of the transition labelled A. (4)

[18]**END OF PAPER: 200 Marks**