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HILTON COLLEGE
GRADE 12 TRIALS EXAMINATIONS
AUGUST 2023

EXAMINATION NUMBER

[illegible]

Total: 200 marks

Moderator: Ms P Mullan

1. This question paper consists of 32 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 30 and 31) are included at the end of the paper. If you run out of space for a question, use this page. If you need another graph for Question 3.2, it is provided on page 32. Clearly indicate at the original question, if you have used the extra space on pages 30 - 32.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Total
Mark										
Marker's initial										
Moderated Mark										
Moderator's initial										
Question Total	20	20	20	23	24	25	25	20	13	200

QUESTION 1: MULTIPLE CHOICE

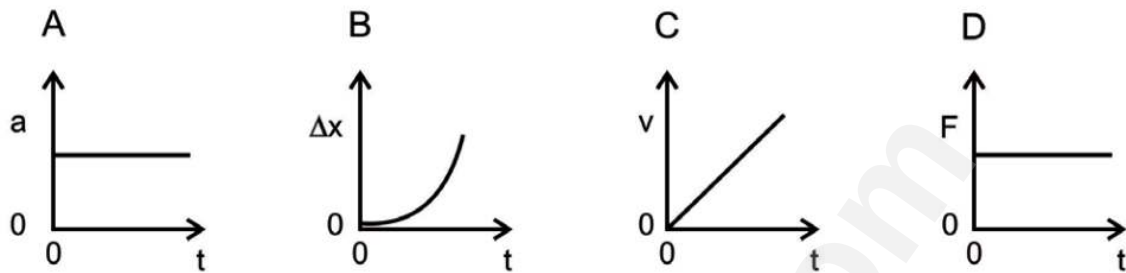
Make a cross (X) in the box corresponding to the letter of the option that you consider to be most correct. Every question has only one correct answer.

A	B	C	D
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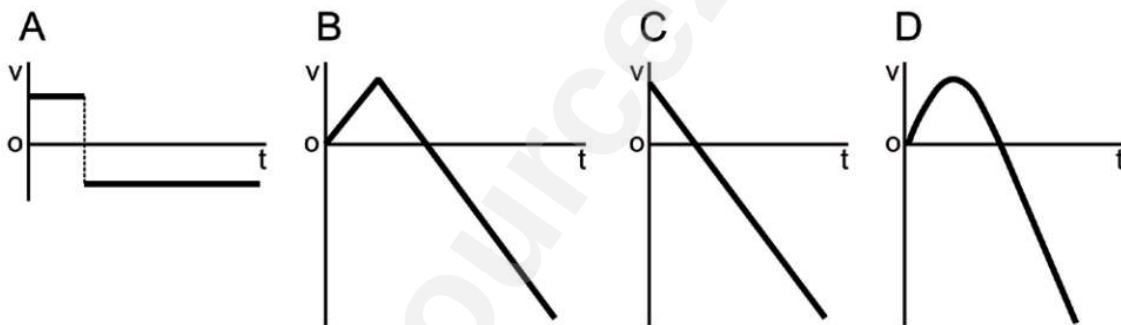
Here the option C has been marked as an example.

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

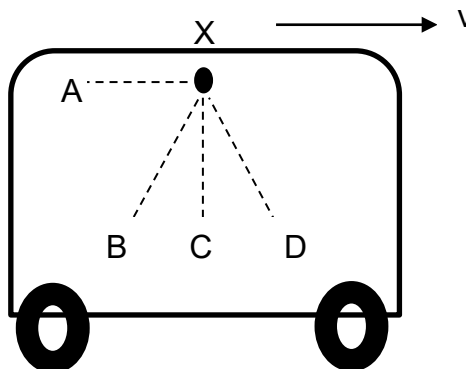
- 1.1 A body is accelerated uniformly from rest. Graphs of acceleration, displacement, velocity and net force against time are shown below. For which of the graphs will the final velocity reached by the body in time t be given by the area under the graph?



- 1.2 While a hot air balloon ascends at a constant velocity, a sandbag drops overboard. Which one of the following velocity vs time graphs best represents the velocity of the sandbag from the time it drops to when it hits the ground? Ignore any effects of air resistance.



- 1.3 A ball is dropped from point X near the ceiling of a railway coach travelling at constant speed v to the right. Relative to a passenger in the coach, which line indicates the path that the ball will follow?



- 1.4 A boy and a girl sit on office chairs, which have wheels attached to them. The chairs are at rest on the horizontal floor. The floor is so smooth that we will assume that it is frictionless. The boy and his chair have greater mass than the girl and her chair.



The boy and girl simultaneously push against each other.

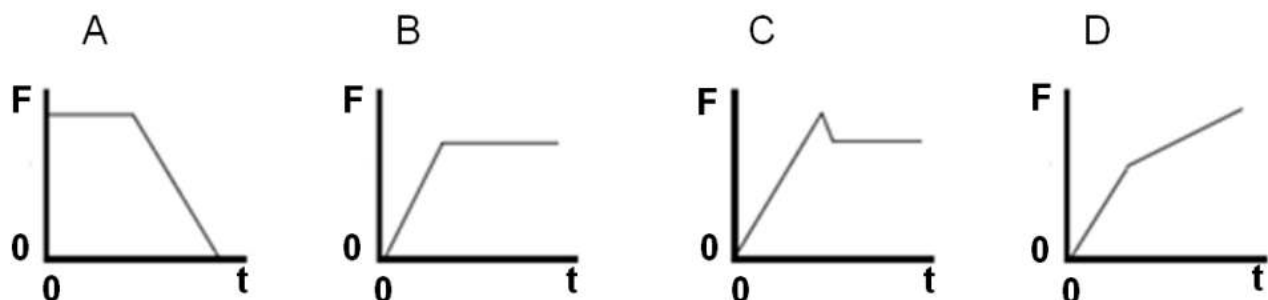
Which of the following statements are both correct regarding their subsequent motion over the first 2 seconds?

	Motion of person in first 2 s.	Reason
A	The boy travels further than the girl.	The force on the boy is greater.
B	The boy travels further than the girl.	His acceleration is greater.
C	The girl travels further than the boy.	The force on the girl is greater.
D	The girl travels further than the boy.	Her acceleration is greater.

- 1.5 A block rests on a rough surface and is attached to a light inextensible string. A force (F) is applied to the block and is gradually increased from zero. The applied force is adjusted so that the block moves along the rough horizontal surface at constant velocity.



Which graph correctly shows how the force applied to the block changes over time while the block is set in motion and then when it moves with constant velocity?



- 1.6 The radius of Neptune is approximately **10 times larger** than the radius of Mercury, and the mass of Neptune is just a little more than **300 times more** than the mass of Mercury.

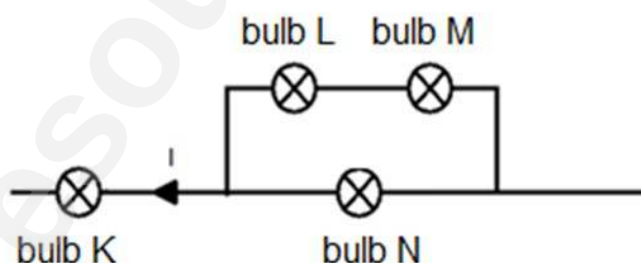
If the magnitude of the gravitational field on Mercury is **g**, the magnitude of the gravitational field on Neptune is approximately equal to ...

- A 3 g
- B 9 g
- C 30 g
- D 90 g

- 1.7 The potential difference between two points in a circuit is numerically equal to the ...

- A charge flowing from one point to the other.
- B charge flowing per second from one point to the other.
- C energy transferred as charge moves from one point to the other.
- D energy used as 1 C of charge flows from one point to the other.

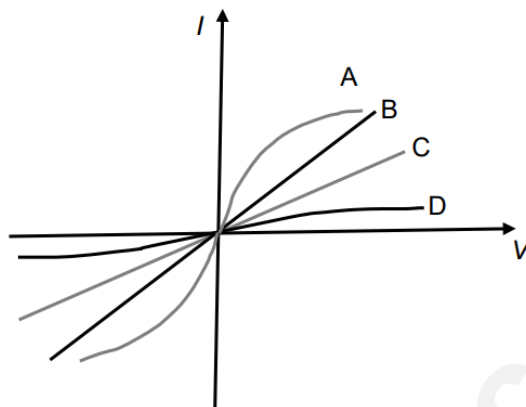
- 1.8 Four identical bulbs, K, L, M and N, with the same resistance, R , are connected in a circuit as shown below. A current, I , flows through bulb, K.



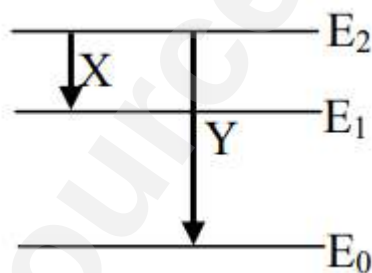
If the power in bulb K is equal to P , which combination of expressions regarding the power in the bulbs L and N is correct? (2)

	Power in bulb L	Power in bulb N
A	$\frac{4}{9} P$	$\frac{1}{9} P$
B	$2 P$	$\frac{1}{2} P$
C	$\frac{1}{2} P$	P
D	$\frac{1}{9} P$	$\frac{4}{9} P$

- 1.9 The graph below shows four relationships between current through a conductor and voltage across the conductor. Which graph shows the behaviour of the ohmic resistor with the highest resistance?



- 1.10 The diagram represents transitions of electrons in the energy levels in a certain atom. Which one of the following statements is true concerning the emission of photons associated with transitions **X** and **Y**?



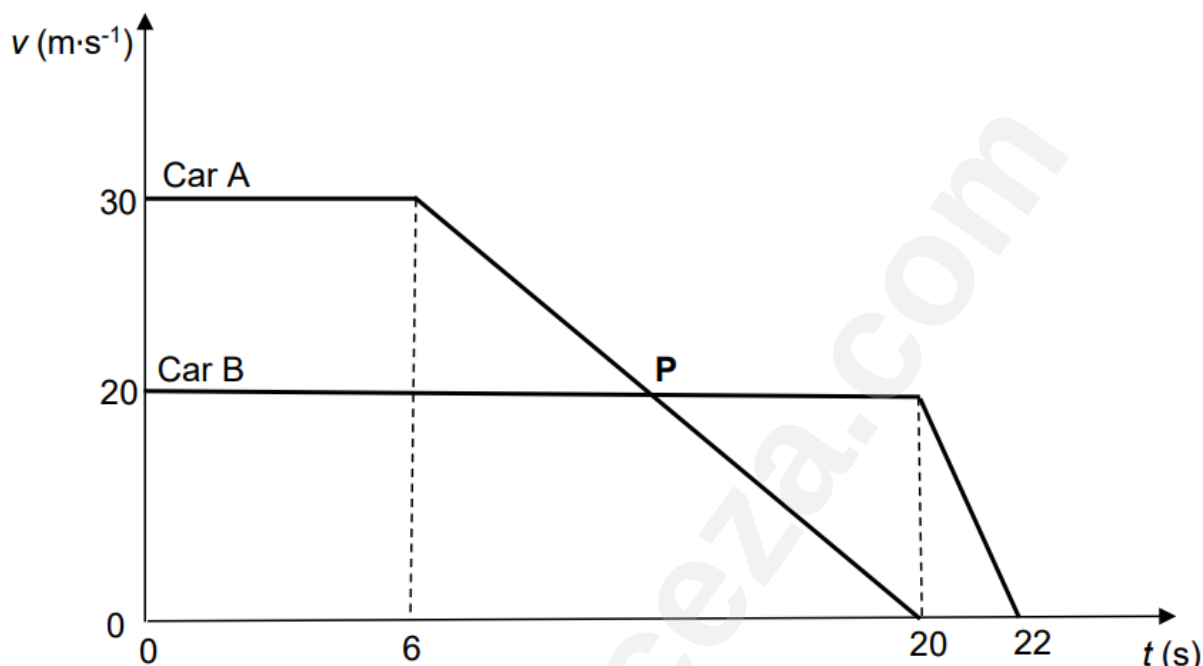
The photon associated with **X** has a greater ...

- A. Frequency than the photon associated with **Y**.
- B. Wavelength than the photon associated with **Y**
- C. Energy than the photon associated with **Y**.
- D. Intensity than the photon associated with **Y**.

[2 x 10 = 20]

QUESTION 2 – KINEMATICS

Car A and **Car B** are travelling **North** along a straight, level road. The velocity–time graph below represents the motion of the two cars.



- 2.1 Define acceleration. (2)
- 2.2 Which car has the greatest instantaneous acceleration? No calculations necessary. (2)
- 2.3 Calculate **car A's** acceleration between 6 seconds and 20 seconds. (4)
- 2.4 What do you know about the cars at **point P**, as shown on the graph? (2)

After 20 seconds, **car A** comes to rest and the driver of **car B** applies the brakes. **Car B** takes 2 seconds to slow down to rest.

2.5 How far does **car A** travel over the 20 second period? (4)

2.6 If the cars come to rest next to each other, how far apart were they at time 0 seconds? (4)

2.7 Which car was leading at $t = 0$ seconds? (2)

[20]

QUESTION 3 – KINEMATICS / GRAPHING

A group of students decided to measure the acceleration due to gravity. They carried out an experiment by dropping a small steel ball (**mass 10 g**) from different heights and measured the time taken (t) for the ball to fall through the particular height (h).

The results are recorded in the table below:

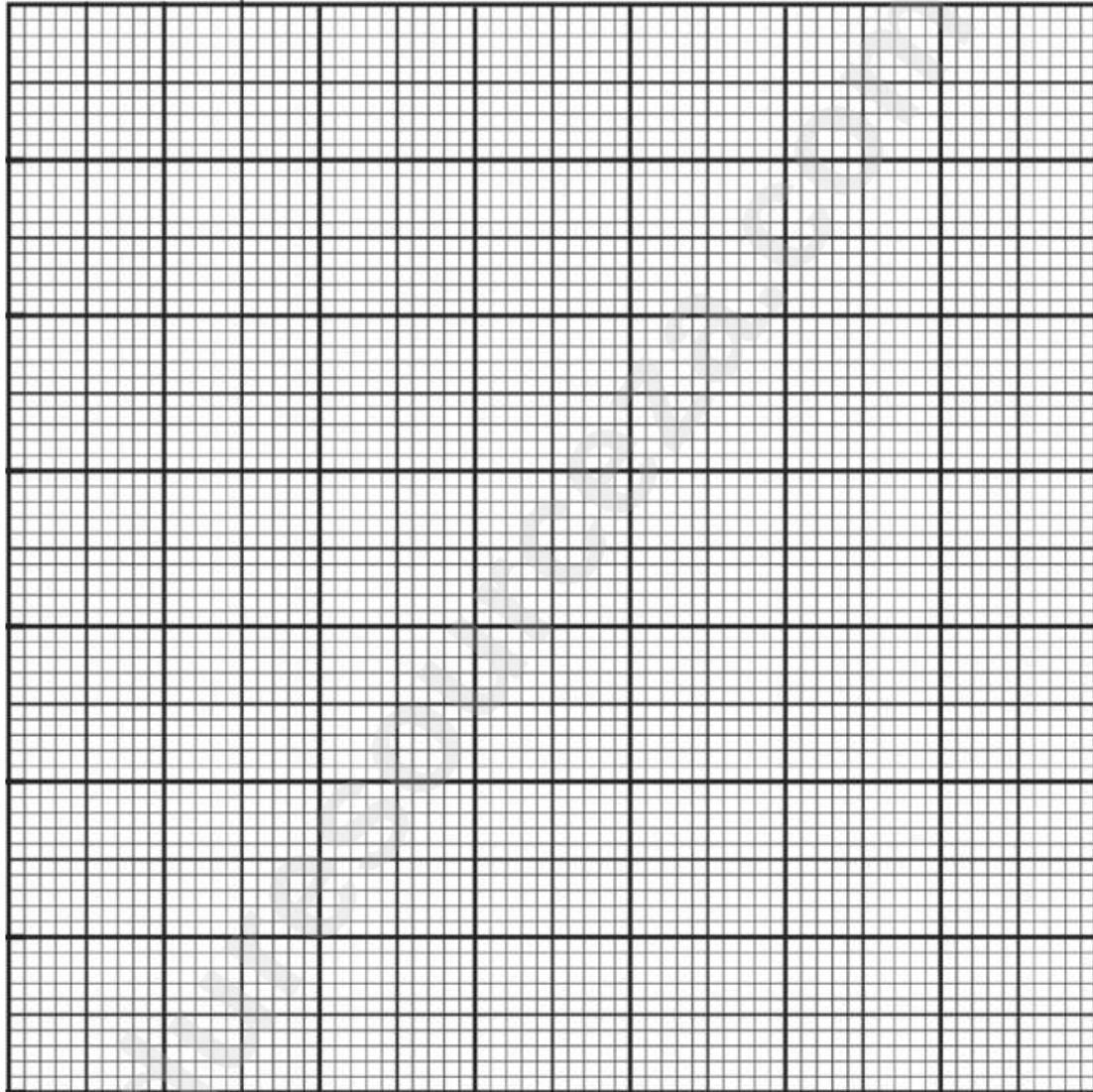
h (m)	t (s)	t^2 (s ²)
0,4	0,27	0,07
0,7	0,40	0,16
1,2	0,47	0,22
1,7	0,60	0,36
2,1	0,64	0,41
2,5	0,72	0,52

The students decided to plot **h vs t^2** .

3.1 Why is it necessary to plot h vs t^2 rather than h vs t ? (3)

3.2 Use the data in the table to plot a graph of h (**y-axis**) vs t^2 (**x-axis**) on the printed graph. Include all the necessary information required for plotting a neat and accurate graph. (6)

Height



Time squared

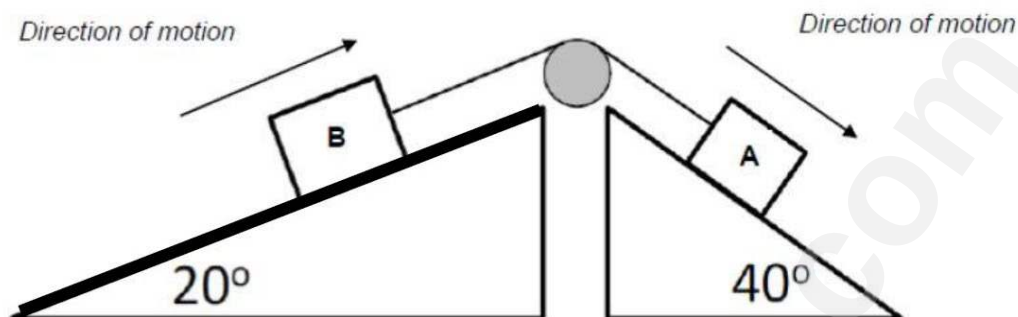
- 3.3 Calculate the gradient of the graph. Indicate the values you used for this calculation on your graph. (4)
- 3.4 Consider the equations of motion and write an equation of motion that describes the relationship between h and t^2 . (2)
- 3.5 Use your answer from Question 3.4 and your knowledge that the equation $y = mx + c$ describes a straight line to determine the acceleration due to gravity. (3)
- 3.6 The students repeated the experiment with a ball of twice the mass (20g). Describe the graph of h vs t^2 for the heavier mass (20g) in comparison with the graph plotted for the 10 g ball. Briefly explain your answer. (2)

[20]

QUESTION 4 – NEWTON'S LAWS

Two blocks, **A** and **B**, are arranged as indicated in the sketch.

- Each has a mass of 3 kg.
- The 40° incline is frictionless.
- The 20° incline has a coefficient of kinetic friction of 0,1.



The objects accelerate in the direction indicated on the sketch.

4.1 State *Newton's Second Law of Motion* in words. (2)

4.2 Draw a free body diagram for the block labelled **B**. (3)

4.3 Define *normal force*. (2)

4.4 Calculate the magnitude of the frictional force acting on block **B**. (4)

4.5 Calculate the magnitude of the acceleration of block **A**. (6)

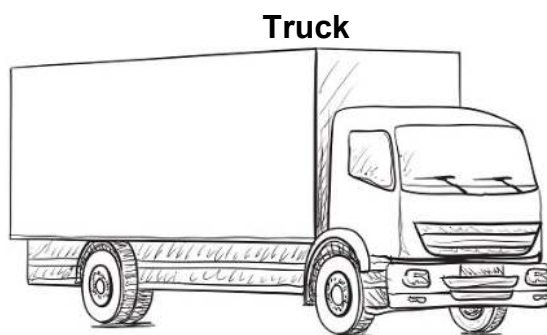
Hint: Use simultaneous equations

4.6 Calculate the magnitude of the tension in the cable. (2)

4.7 The angle of the incline of **block A** is decreased steadily to 30° . What effect does this have on the magnitude of the acceleration of the system? Explain clearly using relevant formulae. No calculations needed. (4)

QUESTION 5 – MOMENTUM, IMPULSE, WEP

- 5.1 A truck of mass 3 500 kg was driving at 20 m.s^{-1} North. The driver fell asleep at the wheel and drove straight through a T-junction, colliding with a barrier in front of him. The truck was stopped by the barrier within a distance of 0,8 m.



Barrier after being crashed into



- 5.1.1 Calculate the change in momentum of the truck during the accident. (4)

- 5.1.2 State the work-energy theorem. (2)

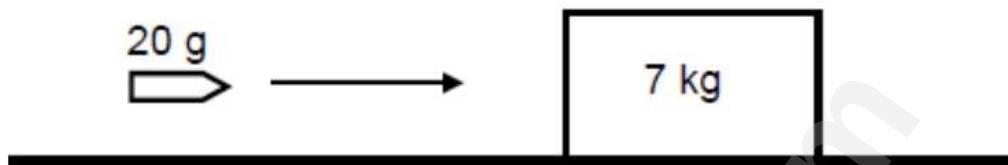
- 5.1.3 Use the **work-energy theorem** to calculate the average resultant force that brought the truck to rest. (4)

Note: you MUST use the work-energy theorem here.

- 5.1.4 Use your answers from Questions 5.1.1 and 5.1.3 to calculate how long it took the truck to come to rest. (3)

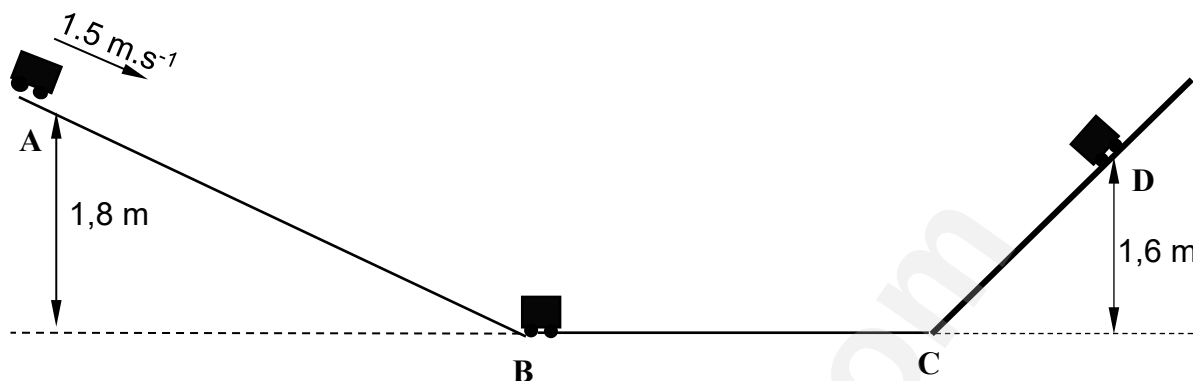
- 5.1.5 Fortunately the driver was not injured during the accident. Explain why the driver could have been more seriously hurt if the same truck had stopped almost instantly. Use a relevant formula to help you in your explanation. (3)

- 5.2 The diagram below shows a bullet of mass 20 g that is travelling horizontally. The bullet strikes a stationary 7 kg block and becomes embedded into it. The bullet and block then travel on a smooth surface at a speed of $1,68 \text{ m.s}^{-1}$.



- 5.2.1 **Name** the law you would use to calculate the velocity of the block immediately after being struck by the bullet. (2)
- 5.2.2 Determine the velocity of the bullet just before it struck the 7 kg block. (4)

- 5.3 A toy car with a mass of 635 g is freewheeling down a frictionless inclined plane **AB**. It passes point **A** with a speed of $1,5 \text{ m}\cdot\text{s}^{-1}$ as shown in the diagram below.



- 5.3.1 Define *mechanical energy*. (2)

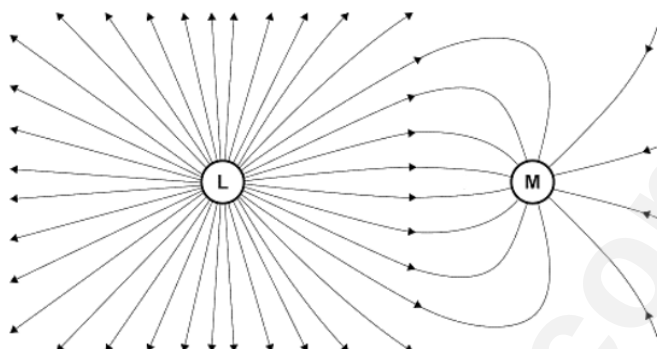
- 5.3.2 If point **A** is 1,8 m above the ground, calculate the **speed** of the toy car at point **B**. (4)

The toy car now moves along the frictionless horizontal plane **BC**.

- 5.3.3 While the toy car is moving up **CD**, it experiences a frictional force of 1,2 N. Use the **law of conservation of energy** to calculate the length of the inclined plane **CD**. (6)

QUESTION 6 - FIELDS

- 6.1 The diagram below shows the field lines for the electric field surrounding two charged objects.



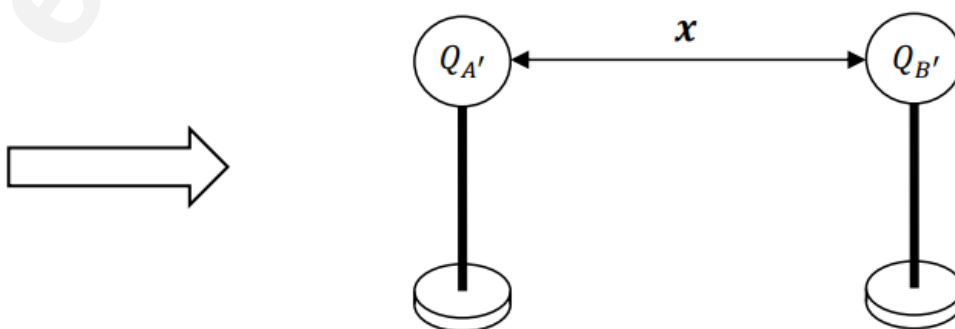
- 6.1.1 Which object, L or M, has a charge with the greater magnitude. (1)

- 6.1.2 Which object, L or M, has a positive charge. (1)

- 6.2 Two charged conducting spheres, supported on insulated stands, are brought together and allowed to touch. The original charges are: $Q_A = +55 \mu\text{C}$; $Q_B = -30 \mu\text{C}$



They are then separated to a distance, x , apart where they experience a force of 8,3 N between them.



6.2.1 State Coulomb's law. (2)

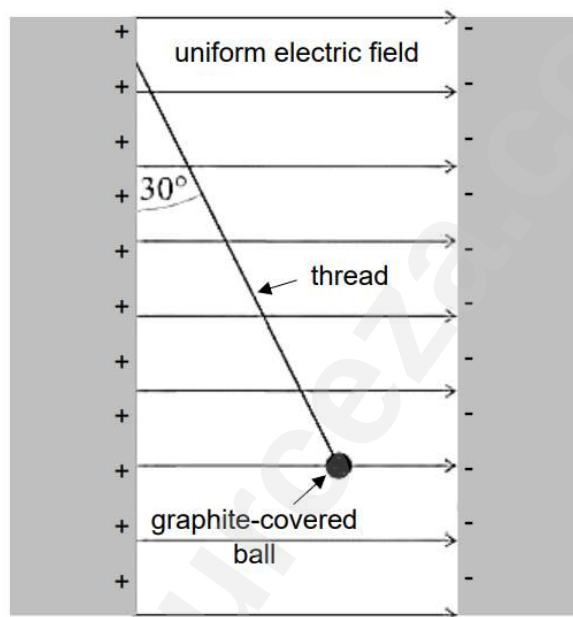
6.2.2 Determine the final distance, x , between the spheres after they have touched and been separated. (6)

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- 6.3 A small, graphite-covered ball carries a positive charge of $+3 \times 10^{-6} \text{ C}$. The ball has a mass of 0,015 kg. The ball is suspended in equilibrium from a vertical plate by an uncharged non-conducting thread of negligible mass.

The left plate is positively charged and, together with the oppositely charged right plate, produces a **uniform** horizontal electric field perpendicular to the plates along the whole of their length.

The diagram below shows that the thread makes an angle of 30° to the left plate.



- 6.3.1 Describe an electric field. (2)

- 6.3.2 Draw a **fully-labelled** force vector diagram showing all forces acting on the ball. Include the relevant angles of the forces acting on the graphite-covered ball, while it is suspended in equilibrium. (3)

- 6.3.3 Hence, determine the magnitude of the strength of the electric field at the position where the graphite-covered ball is suspended. (5)

The thread now breaks.

- 6.3.4 On the diagram at the start of the question, clearly indicate the initial direction that the graphite covered ball will move in.
Note: Use a 5 cm long arrow to indicate this. (1)

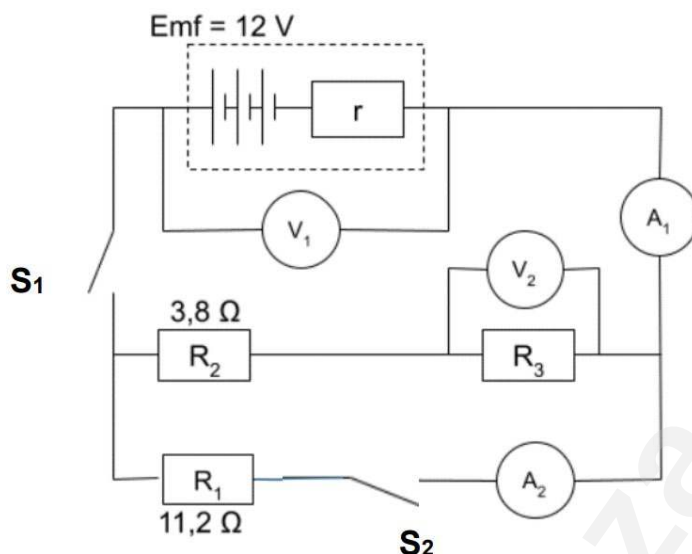
- 6.4 A small mass released from rest just above the surface of Pluto has an acceleration of $0,617 \text{ m.s}^{-2}$. Assume that Pluto has no atmosphere that could provide any resistance to motion.

The radius of Pluto = $1,19 \times 10^6 \text{ m}$. Calculate the mass of Pluto. (4)

[25]

QUESTION 7 – ELECTRIC CIRCUITS

In the circuit represented in the diagram below, the battery has an emf of 12 V and a significant internal resistance, r . The resistance of the ammeters is negligible.



7.1 Switch S_1 is open and S_2 is closed.

7.1.1 Define EMF (2)

7.1.2 State the reading on voltmeter V_1 . (1)

7.1.3 State the reading on voltmeter V_2 . (1)

7.2 Switch S_1 and S_2 is closed.
Ammeter A_1 and A_2 have readings of 1,55 A and 0,96 A respectively.

7.2.1 Calculate the reading on V_1 . (3)

7.2.2 If it costs R1,68 per kWh of electricity, what does it cost to run resistor R_1 continuously for 12 hours. (6)

7.2.3 Calculate the reading on V_2 . (4)

7.2.4 Calculate the internal resistance, r of the battery. (4)

7.3 Two different bulbs, **A** and **B**, are connected in parallel to a potential difference of 12 V. Bulb **A** glows more brightly than bulb **B**.

For the following questions, answer bulb **A**, bulb **B**, or **neither**

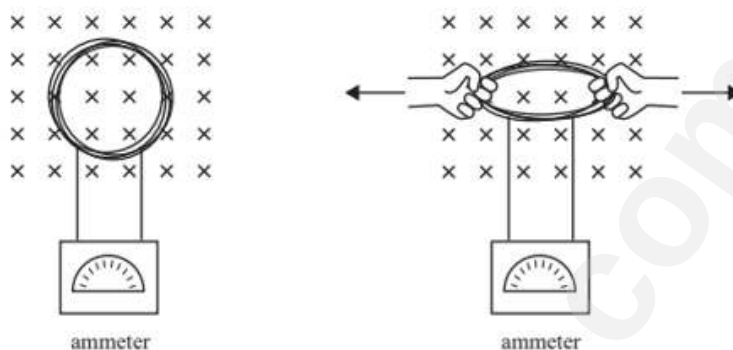
7.3.1 Which bulb has the greater potential difference across it? _____ (2)

7.3.2 Which bulb has the greater current flowing through it? _____ (2)

[25]

QUESTION 8 – ELECTRODYNAMICS

- 8.1 Two students hold a coil of wire in a constant uniform magnetic field. The two images are shown by looking directly down onto the coils from above. The magnetic field runs into the page as you are looking at it.



The students then change the shape of the coil by pulling each side of the coil in the horizontal direction as shown.

When looking from above the circular loop changes into an oval shaped loop as shown in the images.

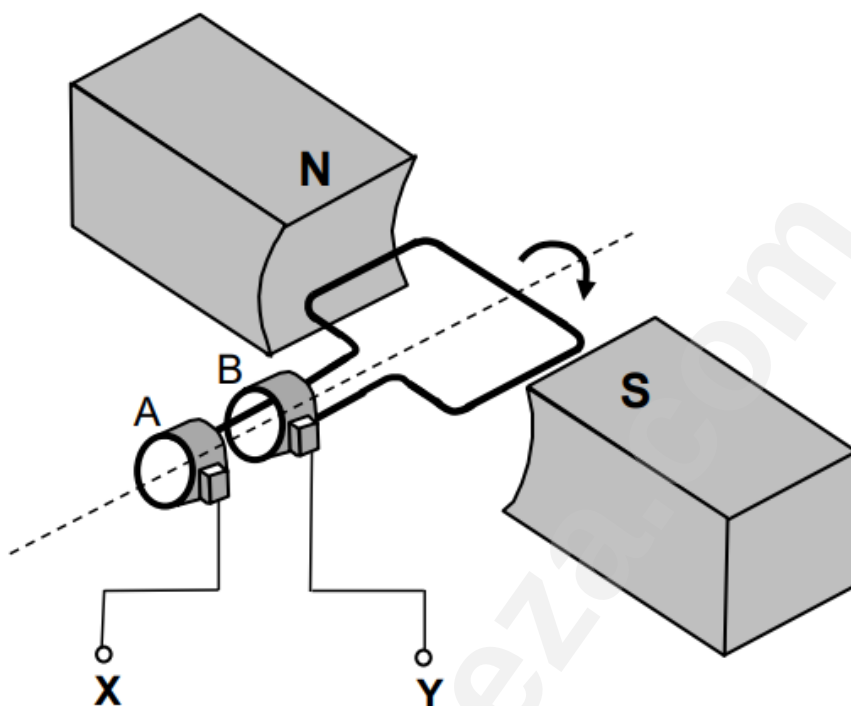
The students notice that a current registers on the ammeter.

- 8.1.1 Will the magnetic flux through the coil INCREASE, DECREASE or STAY THE SAME as the students change the shape of the coil as shown? (2)

- 8.1.2 Explain using physics principles why the ammeter registered a current in the coil. (3)

- 8.1.3 By referring to Lenz's law, **explain** in which direction the induced current flows in the coil. (2)

The diagram below shows a simple generator with a coil that is rotated clockwise in the magnetic field

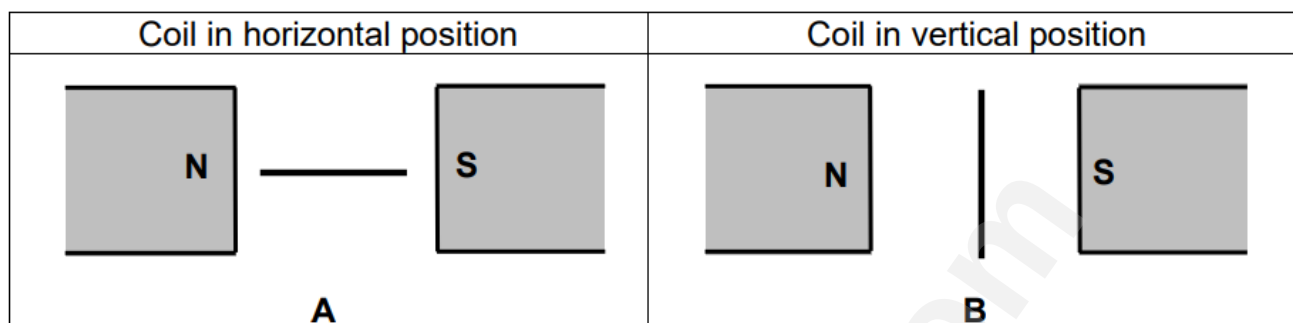


8.2 Name one function of the parts named A and B? (1)

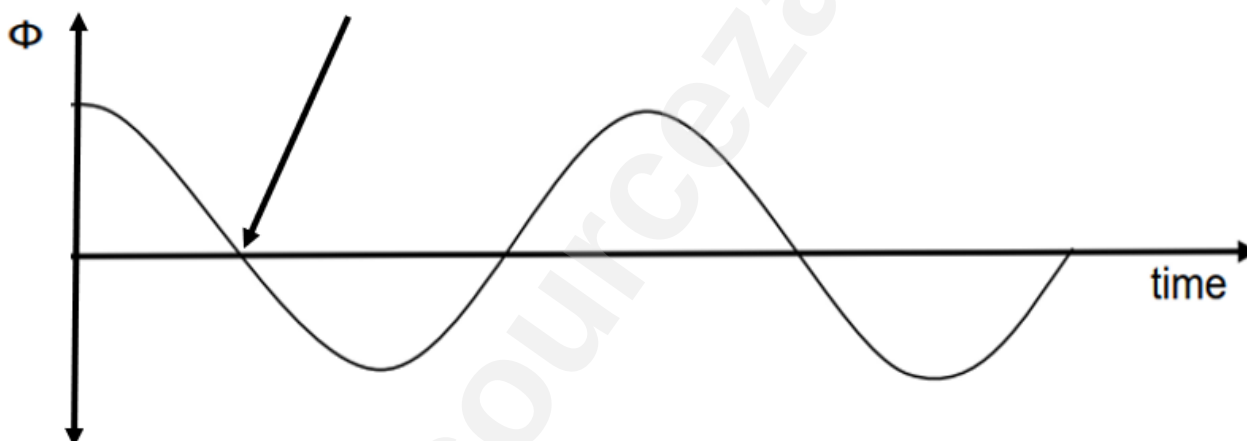
8.3 Explain why current flows in the coil when it is rotated through the magnetic field. (3)

8.4 At the instant shown in the diagram, in which direction will the current flow in an external circuit connected to X and Y? Write only **X to Y** or **Y to X**. (2)

8.5 Two positions of the coil as seen from the axis of rotation are shown below:



The graph below shows the magnetic flux experienced by the coil as it is rotated against time.



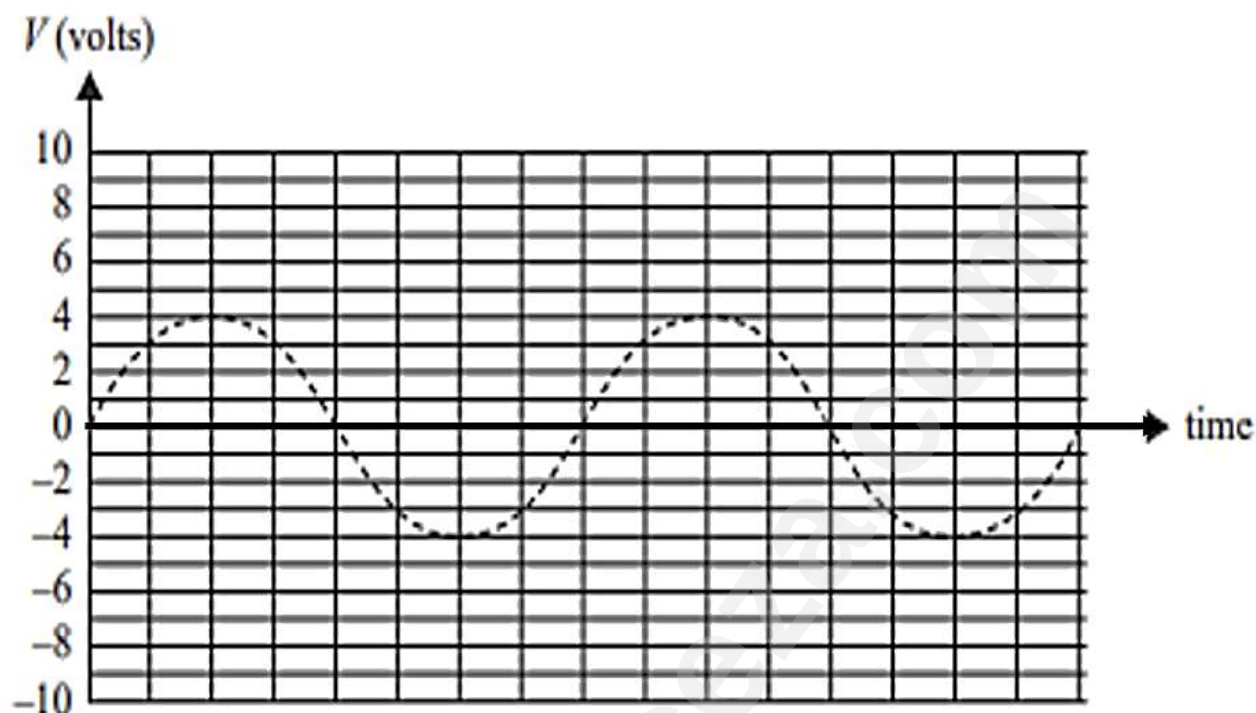
8.5.1 Will the coil be in the horizontal position or the vertical position at the time marked with the arrow on the graph above? (1)

8.5.2 Give a reason for your answer to Question 8.5.1. (2)

8.5.3 Draw a sketch graph on the same axes provided above showing the corresponding **emf induced against time** graph for the rotating coil. There is no need to provide any values.

Clearly label your new line and ideally use another colour when drawing it. (2)

The output of an oscilloscope connected to a **different generator** is shown below.



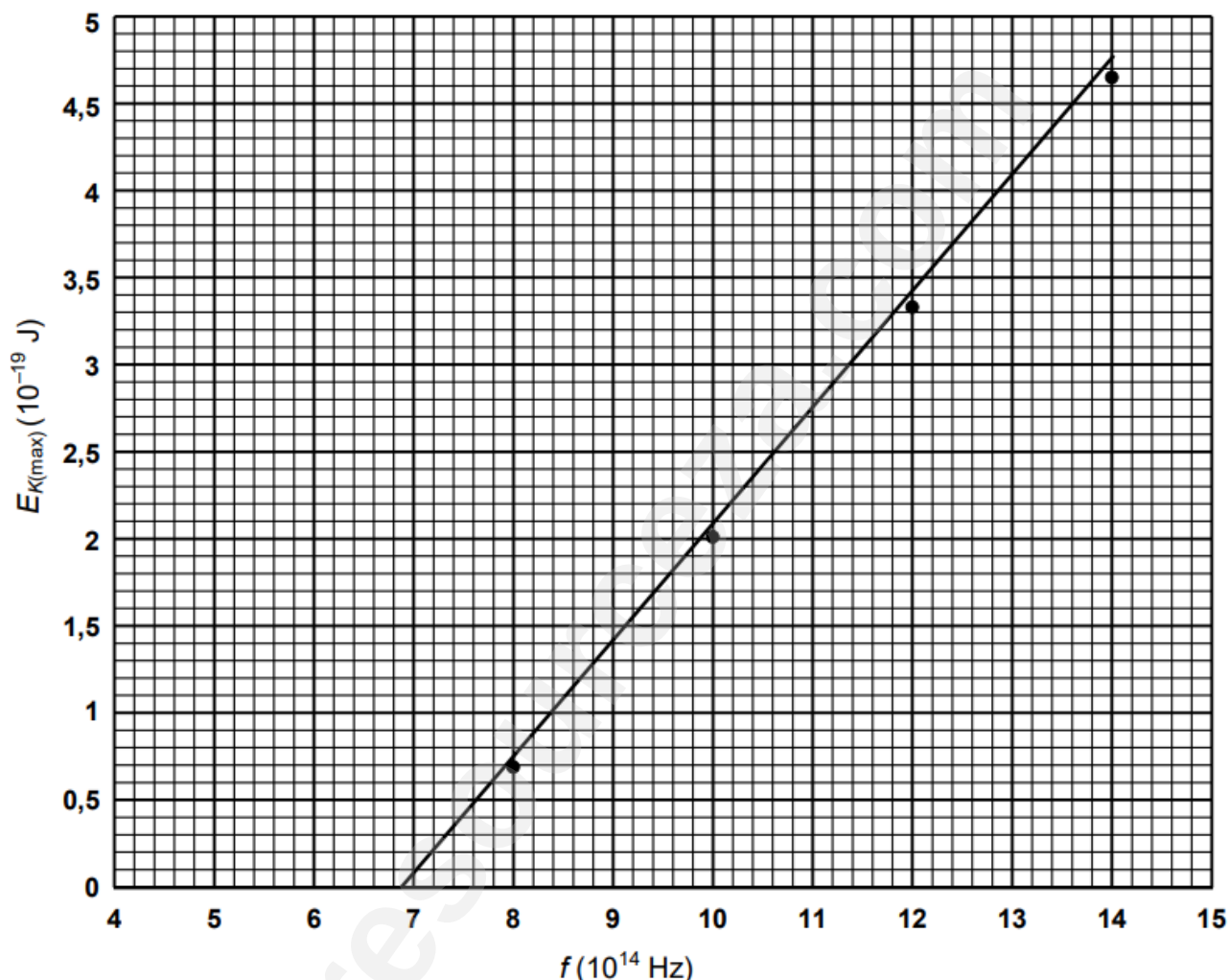
The rate of the rotation of the generator is then **doubled**.

- 8.6. On the graph above, sketch the output that will be seen on the oscilloscope. The original waveform is shown in dashed lines. (2)

[20]

QUESTION 9 – PHOTONS and ELECTRONS

- 9.1 The graph shows how the maximum kinetic energy $E_{K(max)}$ of electrons emitted from a surface of calcium metal varies with the frequency, f , of the incident radiation.



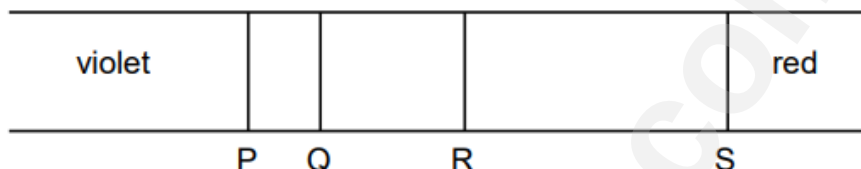
9.1.1 Define work function. (2)

9.1.2 Calculate the work function of calcium. (4)

- 9.1.3 The experiment is repeated using magnesium instead of calcium metal. The work function of magnesium is 1,3 times the work function of calcium.

Draw a second line on the graph to illustrate the results of the experiment with magnesium. (2)

- 9.2 The four emission lines P, Q, R and S in the hydrogen spectrum are illustrated in the diagram.



The wavelengths of the four emission lines are provided in the table:

Emission Line	Wavelength (10^{-7} m)
P	4,10
Q	4,34
R	4,86
S	6,58

Frequencies associated with these wavelengths are emitted when electrons move from a higher energy level to the $-3,4$ eV energy level.

- 9.2.1 Calculate the value of the energy (in Joules) of the light associated with the emission **line S**. (3)

- 9.2.2 Which emission line is produced by the transition from the **highest** energy level to the $-3,4$ eV energy level? Briefly explain your answer. (2)

[13]

TOTAL : 200 marks

ADDITIONAL SPACE (ALL QUESTIONS)

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.**

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ADDITIONAL SPACE (ALL QUESTIONS)

**REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE
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ADDITIONAL GRAPH GRID

REMEMBER TO CLEARLY INDICATE AT THE QUESTION THAT YOU USED THE ADDITIONAL SPACE TO ENSURE THAT ALL ANSWERS ARE MARKED.

