NATIONAL SENIOR CERTIFICATE EXAMINATION
FEBRUARY 2010

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 14 pages;
   - a yellow Answer Booklet of 2 pages (i – ii); and
   - a green booklet of data and formulae of 4 pages (i – iv).

   Please make sure that your question paper is complete.

2. Remove the booklet of data and formulae and the Answer Booklet from the middle of this question paper. **Write your examination number on the yellow Answer Booklet.**

3. Use the data and formulae whenever necessary.

4. Start each question on a new page.

5. Read the questions carefully.

6. In Question 1 answer **EITHER** 1.1 **OR** 1.2.
   In Question 7 answer **EITHER** 7.7 **OR** 7.8.

7. It is in your own interest to write legibly and to set your work out neatly.

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.

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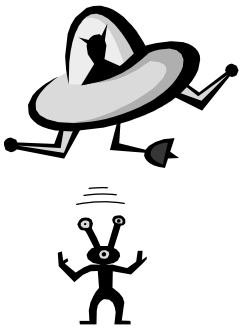
ANSWER EITHER QUESTION 1.1 OR QUESTION 1.2

QUESTION 1

1.1 **Alien Landing?**



A UFO (an Unidentified Flying Object) from a distant planet was on an exploratory visit to Earth. While flying over the Drakensberg mountains the UFO and its occupants were rising vertically at a constant velocity of 15 $m \cdot s^{-1}$, when a young alien astronaut (mass 30 kg) fell out of the spaceship. The young alien lands in a lake below, 4 s after falling out.

1.1.1 Ignoring any effects of air resistance, calculate the speed of the alien when it reached the surface of the lake. (5)

1.1.2 Draw a velocity-time graph for the motion of the alien from the moment it fell from the spaceship until it reached the surface of the lake. Include relevant values on each of the axes. (4)

When the alien struck the surface of the lake, the water applied an average upward force of 1 560 N on its body.

1.1.3 Calculate the depth to which the alien sank in the lake. (7)

OR

1.2 **Medieval Wars**

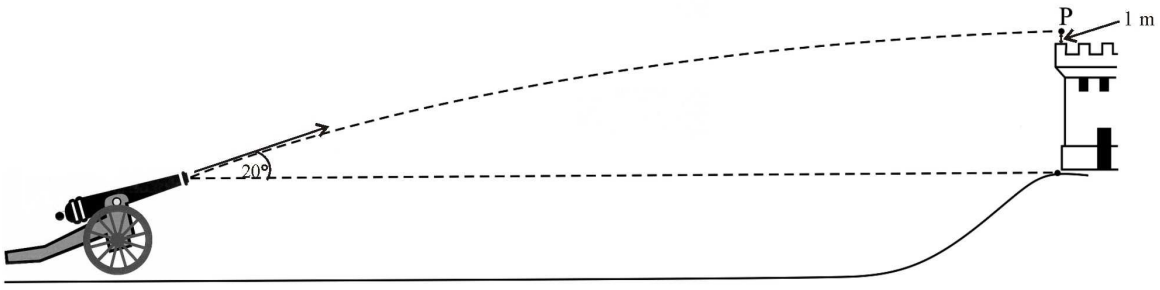


Diagram not to scale.

A cannon fires a cannonball at a castle. The cannonball emerges from the cannon with a velocity of 110 $m \cdot s^{-1}$ at an angle of 20^o to the horizontal, at a point directly in line with the base of the castle. The cannonball reaches its highest point at P when it is 1 m above the top of the castle.

1.2.1 Calculate the height of the top of the castle. (7)

1.2.2 What is the horizontal distance between the cannon and the castle? (9)

16 marks

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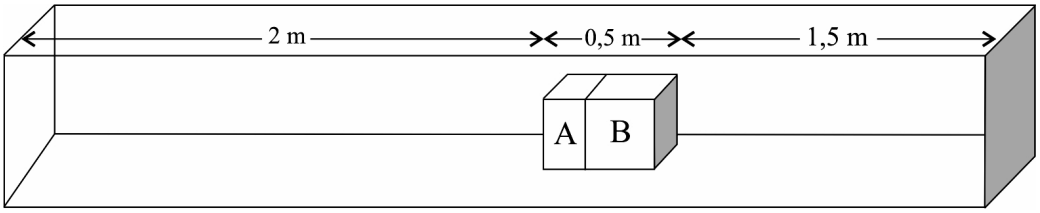
QUESTION 2 DEEP SPACE EXPLOSION

The International Space Station (ISS) is a research facility in outer space. Air resistance is negligible in the ISS and everything in the ISS is at 'zero g'.

2.1 A researcher on the ISS carries out an experiment in which he investigates the Principle of Conservation of Linear Momentum.

An object with a mass of 1,6 kg is suspended inside a tank. The tank and its contents are free to move to the left, right, upwards, downwards, forwards or backwards. Initially, the object is stationary relative to the tank. The object explodes into two pieces, A and B, with m_A = 600 g and m_B = 1 kg. The pieces move apart horizontally until they **stick** to the end walls of the tank. Air resistance is negligible.



2.1.1 State the Principle of Conservation of Linear Momentum. (3)

2.1.2 Piece A moves off with a momentum of 1,8 kg·m·s^{-1} to the left.

(a) What is the momentum of piece B? (2)

(b) Calculate the velocity of Piece A immediately after the explosion. (5)

(c) Which piece (A or B) will be the first to collide with an end wall of the tank? Justify your answer by using calculations. (9)

2.1.3 Immediately after the explosion:

(a) what is the velocity of piece A relative to the velocity of piece B? (2)

(b) how does the impulse on piece A compare with the impulse on piece B? Explain your answer. (4)

2.1.4 After the object explodes into the two pieces, the researcher continues to watch the tank and its contents for several minutes. Describe what was observed during this time. (3)

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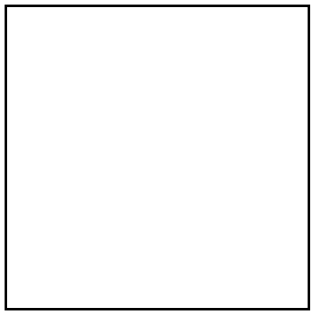
2.2 Read the passage below and consider the evidence for and against the cost of space exploration. Construct a reasoned argument in which you provide an answer to the question:

'Should we spend vast amounts of money on space research and exploration?'

How much does it cost?
Reports indicate that the ISS has cost between R270 billion and R700 billion. It costs about R7 000 million to launch a satellite and there have been at least 5,000 launches since the 1950s. Currently there are approximately 600 satellites orbiting the Earth.

It costs about R3 500 million to build a big new hospital. You can get two hospitals for the price of one satellite launch.

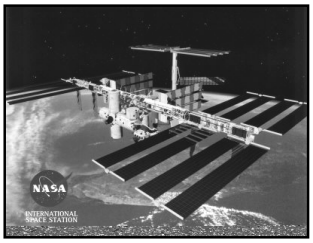


<http://museumvictoria.com.au/pages/2971/GPS_Satellite_NASA_small_3.jpg>

What do we use satellites for?
Satellites have several uses. Some examples are: Google Earth ®, weather forecasting, military espionage, GPS navigation, global TV, international phone calls, internet connections, etc.

What do some people say?
'What many people forget is the human cost of space exploration. Several astronauts have lost their lives. Just one life lost is too many for my liking.'

'No, all the millions spent on space research and exploration could be used to build hospitals, to develop cures for diseases or to pay for programmes that help people who are starving in poorer countries!'



<http://justsap.org/wp-content/uploads/f2160nasa-international-space-station.jpg>

'Money spent on space programmes is important in the communications industry. Satellites in orbit around Earth are used by mobile telephone companies. Satellites are also used by many navigation systems.'

'Space research benefits are not always obvious. Technologies developed for space exploration missions may also have uses in everyday life for you and me. Examples of such technologies are Teflon and sports bras.'

'It is important for our understanding of the Universe that we know as much about our Solar System as possible. If this means spending millions on space exploration missions then so be it.'

[http://www.peep.ac.uk/content/604.0.html]

'Should we spend vast amounts of money on space research and exploration?'

Structure your answer using the framework below:

(a) I think that … (2)
(b) The evidence to support this idea is … (2)
(c) Arguments against me are … (2)
(d) I would counter these arguments by … (2)

36 marks

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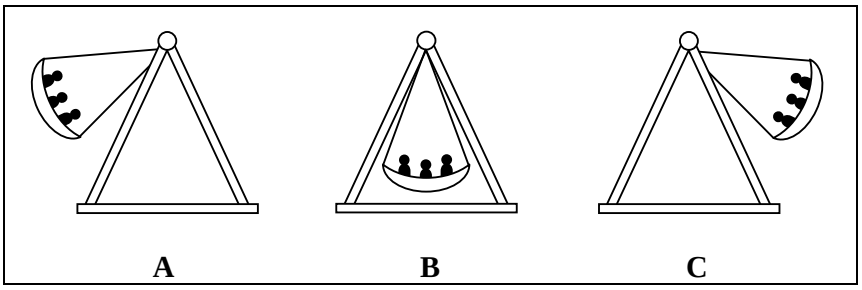
QUESTION 3 THEME PARK RIDE

The 'Coco Pan' is a ride at Gold Reef City. The sketches A, B and C, show the position of the Coco Pan at different times. The motion repeats itself many times between the extreme positions as shown in sketches A and C. Assume the height above the ground of a person, sitting at the centre of the Coco Pan, is the same at position A and C.



As the Coco Pan swings from position A to position B, a man of mass 75 kg sitting at the centre of the Coco Pan gains 5 100 J of kinetic energy.

3.1 Sketch B shows the lowest point reached by the Coco Pan during the swing. Calculate the speed of the man when he is at position B. (4)

3.2 Calculate the man's gain in height, with respect to position B, when the Coco Pan reaches position C. (4)

3.3 Use the set of axes on your answer sheet to draw graphs of the following:

3.3.1 the gravitational potential energy (relative to position B) of the man as the Coco Pan swings from position A to B to C. (3)

3.3.2 and, on the same set of axes, the kinetic energy of the man as the Coco Pan swings from position A to B to C. (3)

3.4 Vusi is a thrill seeker and wants to sit in the most exciting position in the Coco Pan. Where would you advise him to sit in the Coco Pan? Explain your answer. (5)

19 marks

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QUESTION 4 ULTRASOUND

Medical ultrasound has several applications, e.g. it can be used to measure the rate at which blood flows and it can be used to produce images of internal organs and unborn babies.

4.1 What is the Doppler Effect? (3)

4.2 Which of the medical applications mentioned above is an application of the Doppler Effect? (1)

4.3 Often parents' desires and society's interests conflict.

China is asking where all the girls have gone.

The age-old bias for boys, combined with China's draconian one-child policy imposed since 1980, has produced what Gu Baochang, a leading Chinese expert on family planning, described as 'the largest, the highest, and the longest' gender imbalance in the world.

The abortion of female foetuses and infanticide was aided by the spread of cheap and portable ultra-sound scanners in the 1980s. Illegal mobile scanning and backstreet hospitals can provide a sex scan for as little as $50, according to one report.

<http://www.msnbc.msn.com/id/5953508>

4.3.1 Redraw and complete the table below in your answer books: (4)

Table showing the rights and responsibilities when using ultrasound scans to determine the sex of an unborn baby.

	Rights	**Responsibilities**
Parents		
Doctor		To provide a professional service within the realm of the law
Government	To make and enforce laws within the constitution of the country	

4.3.2 Use your answers to 4.3.1 to answer the following question:

Should parents be told their unborn baby's sex?

State your opinion and explain your reasoning in one sentence. (2)

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Bats produce ultrasonic waves. They are able to sense and interpret the reflected wave which they use to determine the distance, size and relative speed of objects in their path.

4.4 The sound wave produced by a Tomb Bat has a frequency of 222 kHz and a wavelength of 0,0015 m. These bats feed mainly on moths, butterflies and termites.

4.4.1 Calculate the speed of this sound wave through the air. (4)

4.4.2 The sound wave is reflected off a stationary moth and is sensed by the stationary bat 0,8 s later. How far is the moth from the bat? (4)

4.4.3 The moth flies towards the stationary Tomb Bat at 12 $m \cdot s^{-1}$.

(a) Calculate the frequency of the sound wave reflected off the moth as received by the bat. (5)

(b) Would the bat perceive the pitch of the sound wave that is reflected by the moth as higher, lower or the same as the pitch reflected by the moth when it was stationary? (1)

24 marks

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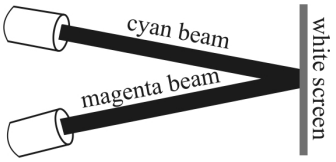
QUESTION 5 THE SCHOOL PLAY

At this year's School play the matric Science class was asked for their assistance with lighting and sound.

5.1 For the opening scene two spotlights of equal intensity, one with a cyan filter and the other with a magenta filter, were shone onto a white screen as shown in the diagram alongside. What is the colour of the 'spot' on the screen? Explain your answer. (4)



5.2 An actress appears on stage and stands in the spot of light created in 5.1. She is wearing a blue shirt with yellow and red dots printed on it. How will her shirt appear to the audience? Explain your answer. (3)

5.3 Thandie and Emily were asked to design the programme for the play. They design the programme using a computer. A yellow rose is printed on the front cover.

The principles of colour mixing that allow the yellow rose to appear on the computer monitor (screen) are very different to the principles of colour mixing used by the inkjet printer to print the yellow rose on paper. Explain briefly how the colours yellow and green are achieved by:

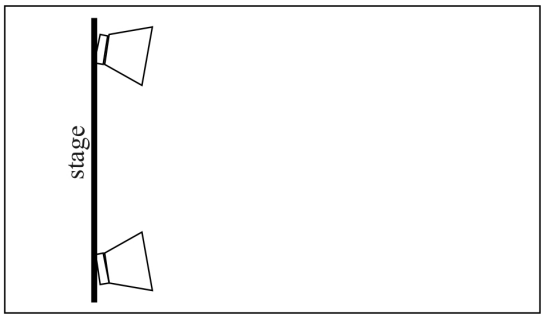
[<http://www.yellowrosecards.co.uk/pictures/yellow%20rose.jpg>]

5.3.1 the computer monitor. (4)

5.3.2 the inkjet printer. (4)

During rehearsals, Peter noticed that the sound appeared to change in some parts of the school hall. The sound is produced by two loudspeakers set-up on either side of the stage as shown in the diagram below.

An aerial view of the school hall



5.4 The diagram of the speakers is reproduced on your answer sheet. The same sound is produced by each speaker.

5.4.1 On your answer sheet, sketch the wavefronts produced by the speakers. (3)

5.4.2 On your diagram, indicate one position in the hall where the sound:

(a) will be loudest (mark the position as A) (1)

(b) will be quietest (mark the position as B) (1)

20 marks

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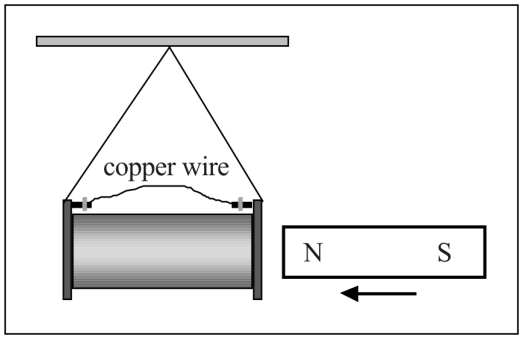
QUESTION 6 ELECTRICAL MACHINES



A solenoid (coil) with a hollow core is suspended using string so that it hangs as shown alongside. The solenoid is free to swing up and down, to the left and to the right, in a pendulum motion.

A strong bar magnet is moved towards the solenoid until the north pole of the magnet enters the solenoid and then the motion of the magnet is stopped.

6.1 Describe what you would observe during the motion of the magnet. (2)

6.2 Explain your predicted observation in 6.1, in terms of any relevant law. Name the law which you have used in your explanation. (5)

6.3 Suggest three ways to increase the effect observed in 6.1. (3)

A kinetic torch (shown alongside) produces electrical energy when it is shaken. In this process, a magnet moves forward and backward through a hollow solenoid that is connected to an LED.

David wants to investigate the relationship between the voltage induced on the ends of the solenoid and the speed with which the magnet moves through it.

[<http://img.alibaba.com/photo/1003734/Kinetic_Torchlight.jpg>]

6.4 Write a hypothesis for David's investigation. (2)

6.5 Kinetic torches make use of LEDs rather than regular torch bulbs. Suggest three benefits of this. (3)

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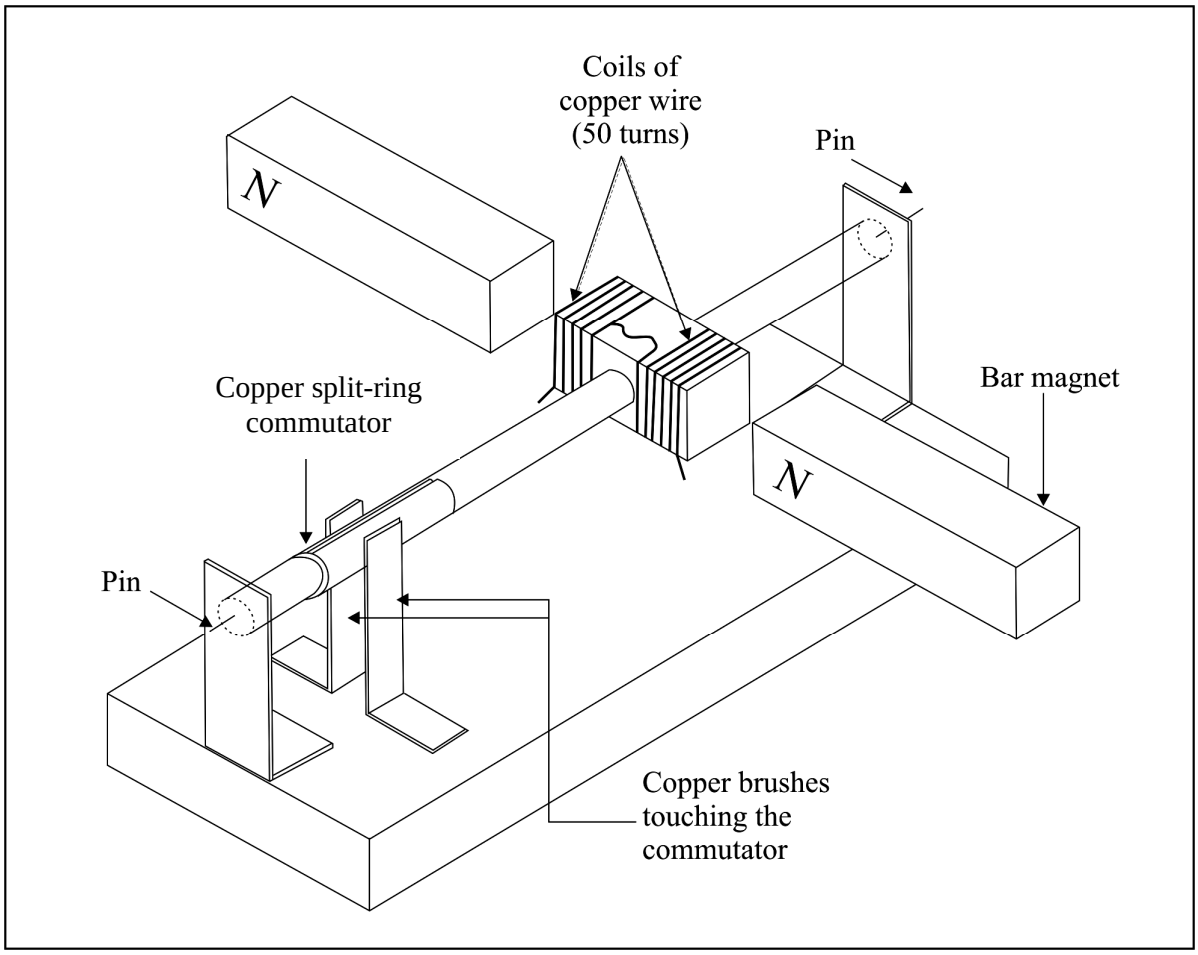
Marcus built a model of a DC motor as shown below. He has made several mistakes. The motor does not work.



[Board of Studies NSW, 2004, *HSC Examination*, p. 18]

6.6 Identify three mistakes that Marcus has made. (3)

Marcus corrects the mistakes he has made. Now he wants to modify his model of a DC motor in order for it to work as an AC generator.

6.7 Suggest three modifications that Marcus must make. (3)

21 marks

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QUESTION 7

The diagram below represents the main regions of the electromagnetic spectrum.

Gamma-rays	X-rays	Ultraviolet	Visible light	Infra-red	Microwaves	Radio waves

7.1 Explain how electromagnetic waves are produced and propagated. (4)

7.2 Which of gamma-rays and radio waves has the longer wavelength? (1)

7.3 Which of gamma-rays and radio waves has the higher energy? (1)

7.4 State one property that all electromagnetic waves have in common. (1)

7.5 Name the type of electromagnetic waves produced by cell phone masts. (1)

7.6 A teacher wants to demonstrate diffraction to his class.

7.6.1 Define diffraction. (2)

7.6.2 Suggest two reasons why he should use visible light for his demonstration rather than x-rays. (2)

QUESTIONS 7.7 AND 7.8 FOLLOW ON THE NEXT PAGE.

ANSWER EITHER 7.7 OR 7.8.

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ANSWER EITHER QUESTION 7.7 OR QUESTION 7.8

7.7 Nuclear physicists have experimented with various materials and their ability to absorb gamma radiation. The table below shows the thickness of different materials needed to absorb 90% of gamma radiation and the energy of that radiation.

Energy ($\times 10^6$ eV)	**Thickness (cm)**			
	Lead	**Steel**	**Concrete**	**Water**
0,5	3,0	8,0	15,0	48,0
1,0	4,5	10,0	25,0	61,0
1,5	4,8	12,0	33,0	72,0
2,0	5,0	14,0	38,0	80,0

7.7.1 (a) Which of the materials is least effective at absorbing gamma radiation? (1)

(b) Use information in the table to give a reason for your answer in (a). (1)

7.7.2 You are in charge of the disposal of used nuclear fuel at a nuclear power plant. The used fuel radiates gamma rays with initial energy of $1,5 \times 10^6$ eV. Using **at least two** of the substances listed in the table above, describe a container that you would design to store the used fuel. Provide reasons for your choice. (4)

OR

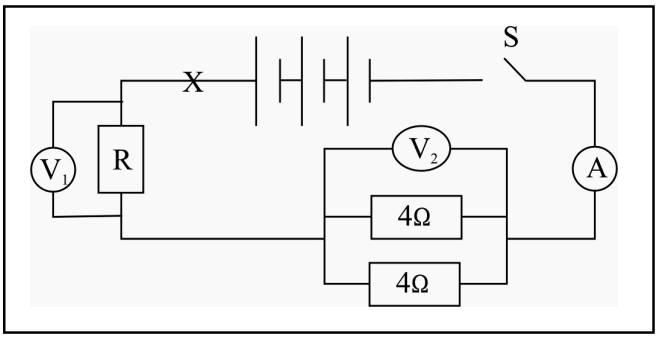
7.8 In the circuit shown below the internal resistance of the battery and that of the ammeter is negligible. When switch **S** in the circuit is closed, the meters V_1, V_2 and A give particular readings. How would the readings on each of the three meters **change** in each of the following cases?

7.8.1 Another 4 Ω resistor is connected in parallel with the others. (3)

7.8.2 A 3 Ω resistor is connected at point X in the original circuit. (3)

Copy the table below and answer *'increase, decrease* or *remains the same'*

	V_1	V_2	A
7.8.1			
7.8.2			



18 marks

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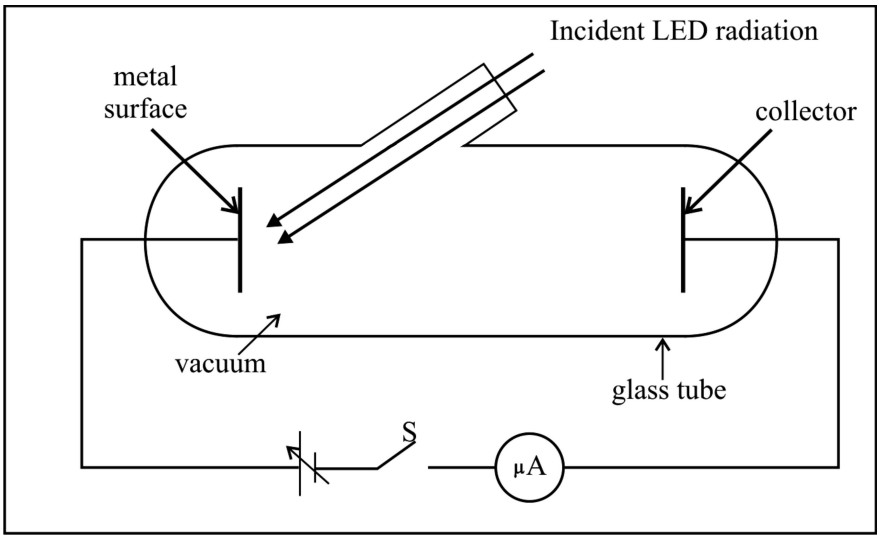
QUESTION 8

Sarah wants to conduct an investigation on the photoelectric effect. Her aim is to determine the work function of some metals. She uses the apparatus shown below. She places samples of caesium, potassium and sodium in turn at the metal surface and irradiates them with the light emitted from a variety of LEDs. She measures the stopping voltage for each metal under that radiation if there is a reading on the microammeter, by adjusting the voltage until the current stops. The voltage at which the current stops is called the stopping voltage.



8.1 What is meant by the work function of a metal? (3)

8.2 Why is the metal surface connected to the positive terminal of the battery? (2)

8.3 Sarah's method is listed below, but she has listed the steps in the incorrect order.

Method:

a. Calculate the frequency of the light emitted from the LED and record this in your table.
b. Select the LED that will be used to irradiate the metal. Record its wavelength in your table.
c. If electrons are ejected (i.e. there is a reading on the microammeter), adjust the voltage on the variable voltage supply until current stops flowing. Record the voltage as the Stopping Voltage in your table.
d. Select the metal to be placed at the surface.
e. Convert the kinetic energy from eV to Joules.
f. Repeat the procedure for the other metals.
g. Use the value for Stopping Voltage to determine the values for kinetic energy in eV.

Provide a correct sequence of steps for the method that Sarah could follow by listing the letters a. to g. in your answer book in the order in which the steps should be followed. (7)

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8.4 Sarah's incomplete table of results for her **experiment with caesium** is shown below.

Colour/range of incident radiation	**Wavelength of incident radiation**	**Frequency (Hz)**	**Stopping voltage (V)**	**Maximum kinetic energy of electrons (eV)**	**Maximum kinetic energy of electrons (J)**
Green	540 nm	$5{,}56 \times 10^{14}$	**(b)**	0,15	$2{,}43 \times 10^{-20}$
Blue	470 nm	$6{,}38 \times 10^{14}$	0,49	0,49	**(c)**
Indigo	440 nm	**(a)**	0,67	0,67	$1{,}08 \times 10^{-19}$
Violet	410 nm	$7{,}32 \times 10^{14}$	0,88	0,88	$1{,}41 \times 10^{-19}$
Ultraviolet	350 nm	$8{,}57 \times 10^{14}$	1,40	1,40	$2{,}23 \times 10^{-19}$

8.4.1 Sarah has not recorded her data in an acceptable manner. What mistake has she made? (1)

8.4.2 Determine the values labelled **a, b** and **c** in the table. (6)

8.4.3 What is the independent variable in this experiment? (1)

8.4.4 Using the axes on the Answer Sheet, plot a best-fit line graph of E_K (eV) versus frequency ($\times 10^{15}$ Hz) for caesium. (5)

8.4.5 Determine the gradient of the graph. Show your method clearly. (4)

8.4.6 To what constant does the value in 8.4.5 correspond? (1)

8.4.7 Use the graph to determine the threshold frequency for caesium. (1)

8.4.8 Determine the work function for caesium. (4)

8.4.9 Are Sarah's results reliable? Explain your answer. (3)

8.5 Sarah looks up the work functions for potassium and sodium in a textbook and finds the following values:

Metal	**w_f: Work function (eV)**
potassium	2,30
sodium	2,75

Using the information about caesium, Sarah tries to predict what the graph of E_K (in eV) versus frequency for potassium might look like. On the same set of axes as the graph in 8.4.4, show the graph that you predict for **potassium**. (3)

8.6 A variety of LEDs were used as light sources of different frequencies. By discussing the internal structure of an LED, explain how it is designed to produce light of a particular colour. (5)

46 marks

Total: 200 marks

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