NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2009

PHYSICAL SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:
   - a question paper of 16 pages;
   - a yellow Answer Sheet 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 data, formulae and answer sheet from the middle of this question paper. **Write your examination number on the yellow Answer Sheet.**

3. Use the data and formulae whenever necessary.

4. Start each question on a new page.

5. Read the questions carefully.

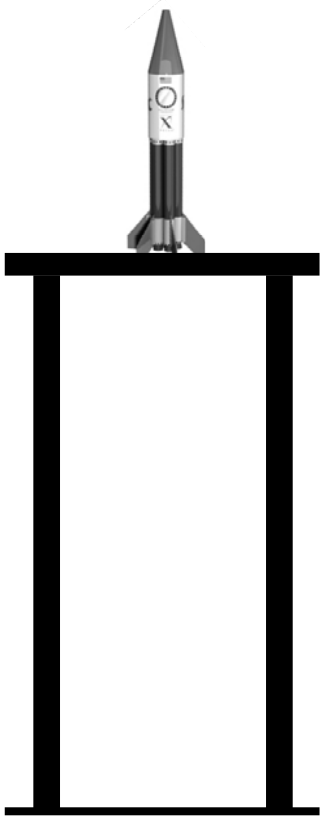
6. In Question 1 answer **EITHER** 1.3 **OR** 1.4.
   In Question 6 answer **EITHER** 6.2 **OR** 6.3.

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

8. Show your working in all calculations.

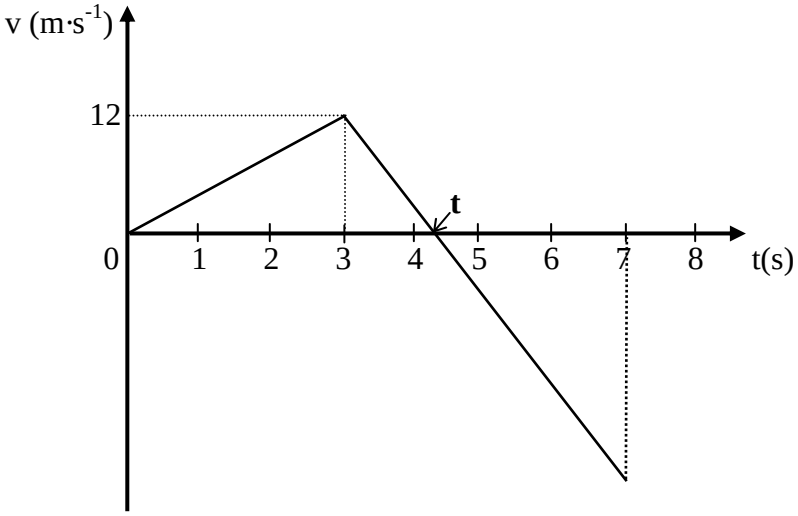
9. Units need not be included in the working of calculations, but appropriate units should be shown in the answer.

QUESTION 1 ROCKET SCIENCE



John designed and constructed a model rocket. He placed it on top of a high platform to allow his friends to get the best possible view.

He recorded the launch on a video tape. Using the video tape, John was able to plot the following velocity-time graph of his rocket's motion.



1.1 For the first 3 seconds:

1.1.1 describe the motion of the rocket. (4)

1.1.2 draw and label a free-body diagram of the forces acting on the rocket. (4)

1.2 After 3 seconds, all of the rocket fuel is burnt up and the rocket is now in free-fall.

1.2.1 What is the gradient of the graph between t = 3 s and t = 7 s? (1)

1.2.2 Determine the time at **t**. (6)

ANSWER QUESTION 1.3 OR 1.4

1.3 1.3.1
- Draw a displacement-time graph for the motion of the rocket using the axes provided on the Answer Sheet.
- Some points have already been plotted for you on the Answer Sheet.
- Provide values for the displacements labelled X, Y and Z on the axes. Show your method. (9)

1.3.2 From your graph in 1.3.1 determine the height of the platform. (1)

ONLY ANSWER QUESTION 1.4 IF YOU DID NOT ANSWER QUESTION 1.3

1.4 At t = 3 s, when the rocket has burnt up all its fuel, a steady wind blowing at 9 $m \cdot s^{-1}$ from the left moves it off course from the vertical.

1.4.1 Determine, by scale diagram or by calculation, the velocity of the rocket relative to the ground at t = 3 s. (6)

1.4.2 How far will the rocket be displaced from the platform when it reaches the ground? (4)

Read the following information before answering Questions 1.5 to 1.9 on the next page.

While designing and constructing his rocket, John had to learn about the local safety codes and various certification processes for amateur rocketry. The safety codes give details of preflight inspections, operating clearances, user qualifications, etc.

Rocket motors are classified with a code, ranging from A to O, that shows the total impulse on the rocket (measured in N·s).

Class	Impulse (N·s)
A	2,5
C	9,0
H	160
O	40 000

Below is the label from one of John's rocket motors.

TYPE AND PRIMARY USE		
C 6–4	206	SINGLE STAGE

The code C 6–4 gives the following information:
- C – the total impulse of the motor is 9 N·s
- 6 – the average thrust (measured in N)
- 4 – the time delay between burnout and recovery (measured in s)

1.5 Define impulse. (3)

1.6 Below is a table summarising some SI base units.

Physical Quantity	**Symbol**	**Unit**	**Symbol**
amount of matter	n	mole	mol
current strength	I	ampere	A
length	Δx or d or s	metre	m
mass	m	kilogram	kg
temperature	T	kelvin	K
time	t	second	s

The total impulse of a rocket motor is measured in newton seconds. Express this unit in terms of SI base units. Show your working. (3)

1.7 For a particular rocket motor coded as a C 6-4 motor, use the information on the previous page to calculate the length of time that this motor exerts a force on the rocket. (4)

Launching a 'High Power Rocket' requires the operator to be certified, i.e. he/she needs to pass tests to qualify for a license. A 'High Power Rocket' is one with an H-class motor or higher and a minimum mass of 1 500 g.

1.8 Use the information about motor classification and the text above to evaluate whether there is a necessity for an operator to be licensed. Calculations of appropriate distances or speeds must be used to support your answer. (9)

1.9 1.9.1 Define the term Mach number. (2)

1.9.2 An M-class motor provides the rocket with a maximum speed of 105 $m \cdot s^{-1}$. The speed of sound in air is 330 $m \cdot s^{-1}$. Calculate the Mach number of the rocket. (3)

1.9.3 Would this rocket (in 1.9.2) be classified as *subsonic* or *supersonic*? (1)

1.9.4 High Power Rockets are sometimes referred to as 'Mach-speed projectiles'. Comment on this description. (2)

1.9.5 In your opinion, can rocketeering be regarded as a hobby when finger-printing, background checks and licensing of individuals becomes necessary? (4)

56 marks

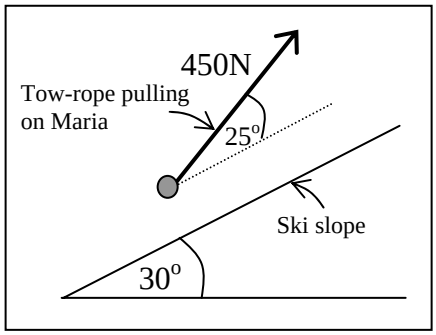
QUESTION 2 A SKIING HOLIDAY

Each winter it snows on some of the mountains of the Eastern Cape. Ski resorts in the area also make artificial snow so that South Africans can enjoy as many winter sports as possible without having to go overseas.

2.1 Maria is a beginner and is learning to ski on the gentle slopes. Maria uses a 'T-bar' lift to get to the top of the slope.

At the 'T-bar' lift station, there is a sign such as the one depicted on the right that is designed to instruct first-time users on how to use the lift.

Maria's friend, Thabo, prepared the following sketch of the situation and added figures that he felt were appropriate.



The tension of 450 N in the tow-rope allowed Maria to be pulled up the slope at a constant speed of 1 $m \cdot s^{-1}$.

2.1.1 Show that the component of the tension in the tow-rope parallel to the slope is 407,84 N. (2)

2.1.2 What is the magnitude of the force that opposes Maria's motion up the slope? (1)

2.1.3 How much work is done by the opposing force when Maria is pulled a distance of 20 m up the slope? (4)

2.1.4 How much power is required to pull Maria to the top of the ski slope? (4)

2.1.5 The 'T-bar' lift is driven by an electric motor.

(a) Why would the power output of the electric motor need to be larger than your answer to 2.1.4? (2)

(b) Suggest three ways to increase the power output of the electric motor. (3)

2.2 The children enjoy racing down the slopes on a sled. Travis wondered if a sled accelerated uniformly down the slope. He set his cellphone to beep every second while he came down the slope on the sled. He made a mark in the snow every time the cellphone beeped. Then he walked back up the slope with a long measuring tape. He measured five consecutive lengths that he had marked on the slope.

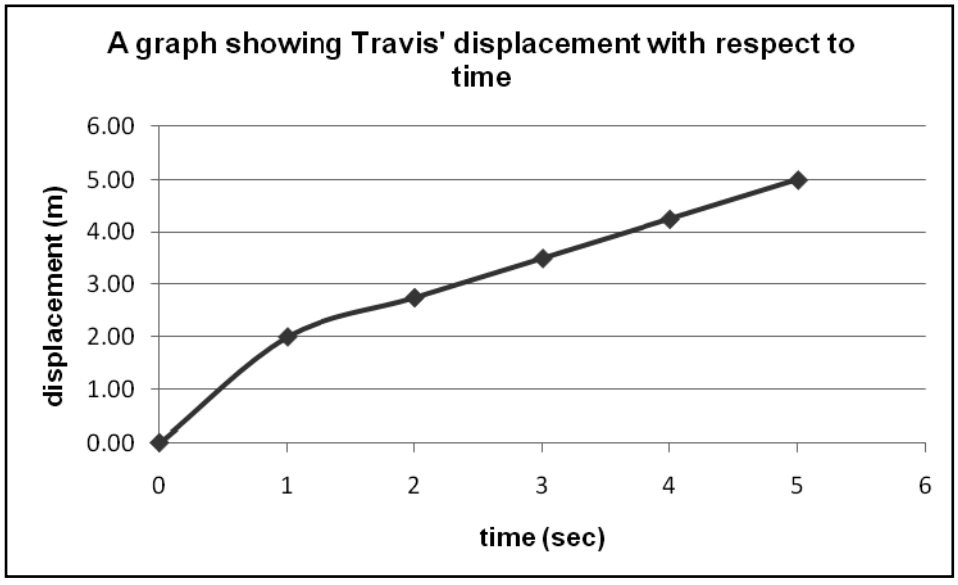
2.2.1 Comment on the method used in Travis' experiment. Will it provide him with accurate results? Explain briefly. (3)

Below are five consecutive lengths that he measured.

2 m
2,75 m
3,5 m
4,25 m
5 m

2.2.2 How will Travis know that the sled accelerates uniformly? (3)

2.2.3 Travis recorded his data on the graph below. He has made several errors. Identify three of his mistakes. (3)



2.3 Thabo and his friend Maria travel in a chair lift to the top of the highest slope. The chairlift moves at 3 m·s^{-1}.

2.3.1 What is Thabo's velocity relative to Maria? (1)

Thabo and Maria see two of their friends on the slopes below. At this point in time, Shazia is skiing down the slope at 12 m·s^{-1} and Travis is ahead of her going downhill on his sled at 5 m·s^{-1}.

2.3.2 What is Travis' velocity relative to Shazia? (2)

2.3.3 What is Travis' velocity relative to Maria? (2)

30 marks

QUESTION 3 A TRIP TO THE FIRE STATION

Daniel's Grade 4 class visited the fire station. They rode on a fire engine which had a flashing red light on the roof and a hooter that emits a sound with a frequency of 250 Hz.

After the ride, the fire engine went out on a call. It raced away from the children at 20 m·s^{-1} with its hooter blaring and its red light flashing. Daniel noticed that the sound of the hooter seemed to change when the fire engine moved away from him.

(Take the speed of sound in air as 330 m·s^{-1})

3.1 Name the effect that Daniel is observing. (1)

3.2 Calculate the apparent frequency of the sound from the hooter when the fire engine is moving **away** from Daniel at a speed of 20 m·s^{-1}. (5)

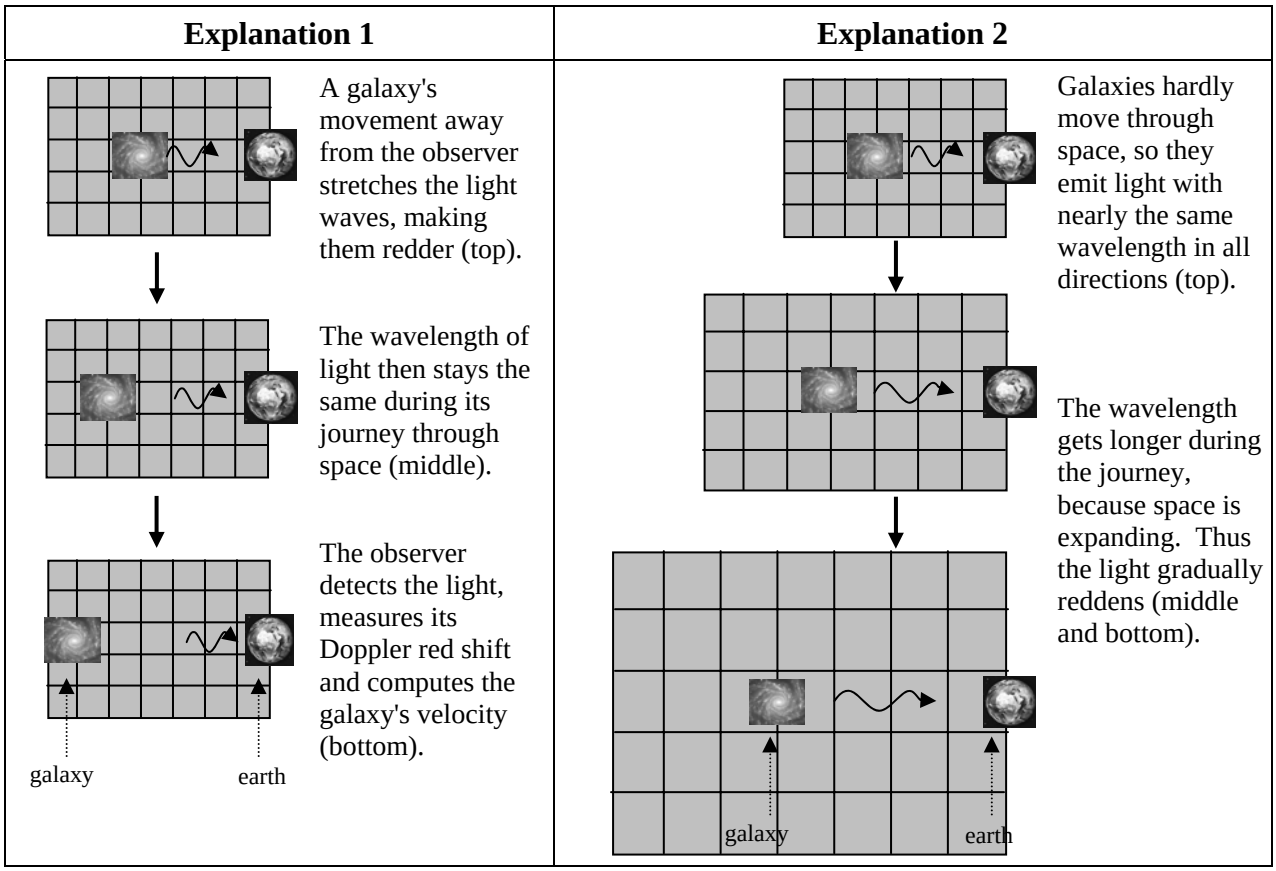
3.3 Draw a diagram to show the advancing wavefronts that are produced by the hooter when the fire engine moves away from Daniel. In your diagram, indicate Daniel's position and the direction of the fire engine's velocity. (2)

3.4 There is a noticeable change in the hooter's frequency, but not a noticeable change in the colour of the flashing red light as the fire engine changes speed and direction. Explain these observations. (3)

11 marks

QUESTION 4 MODERN THEORIES OF THE RED SHIFT

Modern astronomers have observed that the wavelength of light travelling from distant galaxies towards Earth is shifted towards the red end of the spectrum. Astronomers have found different ways to explain this 'cosmic red shift'. Two such explanations are shown below:



[Lineweaver, CH & Davis, TM 2005, 'Misconceptions about the Big Bang', *Popular Mechanics*, May 2005, p. 35.]

4.1 What have 'cosmic red shifts' led astronomers to conclude? (2)

4.2 Carefully examine the sequence of diagrams in Explanation 1 and then do the same for Explanation 2.

4.2.1 Which explanation shows that the galaxy has a zero velocity relative to space? (1)

4.2.2 Which explanation shows that space itself is changing? (1)

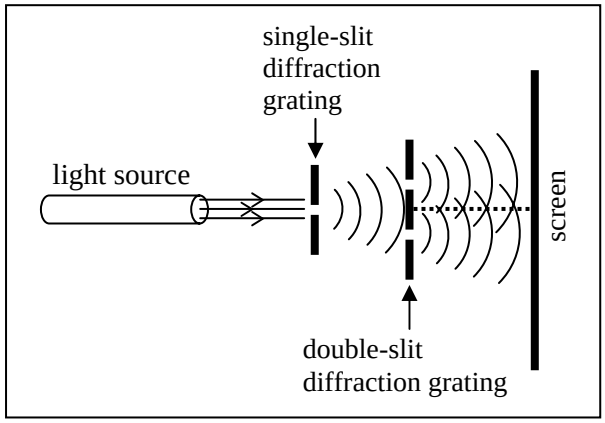
4.3 Which sequence of these diagrams above best explains 'cosmic red shifts'? Explain your answer. (3)

7 marks

QUESTION 5 UNDERSTANDING LIGHT

In 1801, Thomas Young conducted his famous double-slit experiment. He passed light through a double-slit *diffraction* grating and observed the *interference* fringes that were projected onto a screen.

The apparatus shown in the diagram alongside can also be used to determine the wavelength of various sources of light.



5.1 Define diffraction. (2)

5.2 The diagram shows a dotted line (·····). Does this indicate a region of constructive interference or destructive interference? (1)

An experiment is conducted to determine the relationship between the frequency of different coloured light sources and their wavelengths using the apparatus above. The results are as follows:

Colour	***f*: Frequency (Hz)**	**λ: Wavelength (nm)**
Red	$4{,}54 \times 10^{14}$	660
Orange	$4{,}92 \times 10^{14}$	610
Yellow	$5{,}17 \times 10^{14}$	580
Green	$5{,}56 \times 10^{14}$	540
Blue	$6{,}38 \times 10^{14}$	470
Indigo	$6{,}82 \times 10^{14}$	440
Violet	$7{,}32 \times 10^{14}$	410

5.3 The table shows that wavelength is measured in nm (nanometres). Convert 660 nm to m. (1)

5.4 On the graph paper provided on the Answer Sheet, plot a line of best fit to show the relationship between the wavelength of the light and the inverse of its frequency $\left(\frac{1}{f}\right)$.

The scale for *the inverse of frequency* $\left(\frac{1}{f}\right)$ has been marked for you. (5)

5.5 Describe, in words, the relationship between the frequency of a light source and its wavelength. (1)

5.6 Determine the gradient of your graph. Clearly indicate your method on your graph. (3)

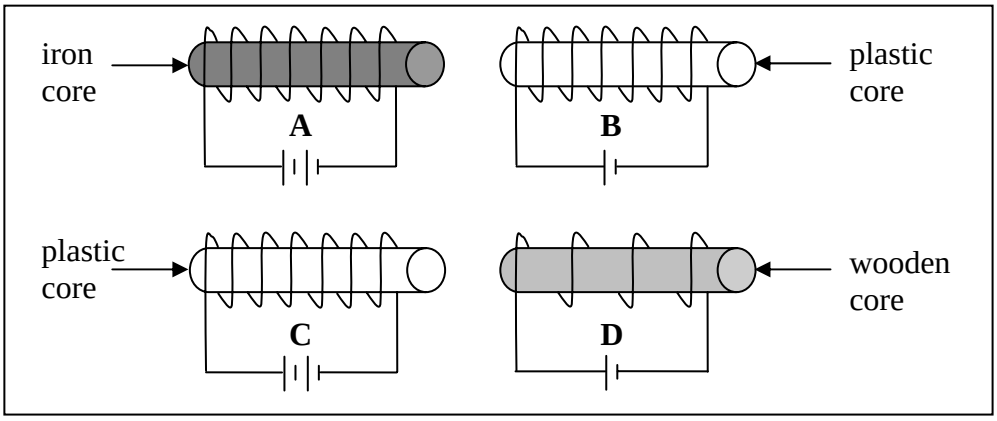
5.7 To which physical constant does the gradient of your graph correspond? (1)

5.8 **Use the information gained from the graph** to write a mathematical relationship between the frequency of a light source and its wavelength. (2)

16 marks

QUESTION 6 INVESTIGATING ELECTROMAGNETISM

6.1 Asiya and Amy conduct an investigation to help them understand electromagnets. They know that magnetic fields are produced by current-carrying conductors. They started their investigation by studying the following arrangements of coiled conductors.



6.1.1 The girls try to predict which arrangement would produce the greatest magnetic field. Make your own prediction and list the arrangements, by writing the appropriate letter, in order from the strongest magnetic field to the weakest magnetic field. (4)

6.1.2 Formulate a hypothesis for an investigation on the effect of the core material on the performance of the electromagnet. (3)

Asiya and Amy are now ready to start experimenting in a more formal manner. They connect each of the electromagnets, A, B, C and D (as illustrated above) to compare the relative strengths of the magnetic fields.

6.1.3 Suggest a method that can be used to compare the relative strengths of the magnetic fields. (2)

Using their method suggested in 6.1.3, they claim that they will be able to determine which material is the best to use for the core of the electromagnet.

6.1.4 What is the independent variable for their experiment? (1)

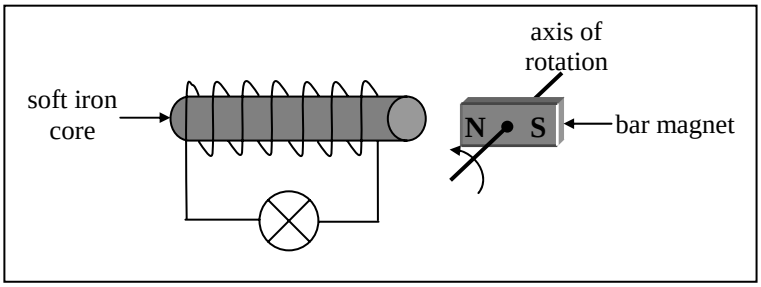
6.1.5 What is the dependent variable for their experiment? (1)

6.1.6 Would this experiment enable the girls to determine which material is the best to use for the core of the electromagnet? Justify your answer. (5)

6.1.7 Suggest two improvements that can be made to the girls' arrangement of coiled conductors. (2)

ANSWER QUESTION 6.2 OR 6.3

6.2 The girls also know that a changing magnetic field can induce an emf in a coil of wire. They experiment with the apparatus below:



The bar magnet is rotated anti-clockwise, by turning a handle. When the bar magnet rotates, the bulb that is connected to the coil glows. The magnet takes 0,5 s to complete 1 revolution.

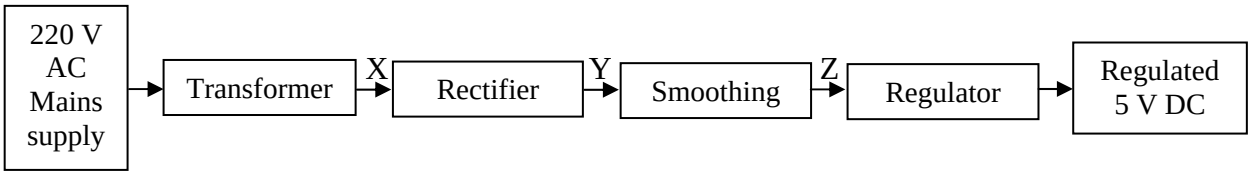
6.2.1 Explain why an emf is induced in the coil when the magnet rotates. (4)

6.2.2 Sketch a graph to show how the induced emf varies with time. Provide a suitable scale along the time axis. Let the position of the magnet as shown above correspond with t = 0 s. (3)

6.2.3 State two changes that can be made to this apparatus that will increase the brightness of the bulb. (2)

ONLY ANSWER 6.3 IF YOU DID NOT ANSWER QUESTION 6.2

6.3 Below is a schematic diagram showing how the AC mains supply to our homes is converted to a DC supply. This describes the process by which devices such as cellphone chargers work.



6.3.1 (a) What kind of transformer is used here? (Step-up or step-down?) (1)
(b) Draw a sketch graph of voltage versus time at point X. (2)

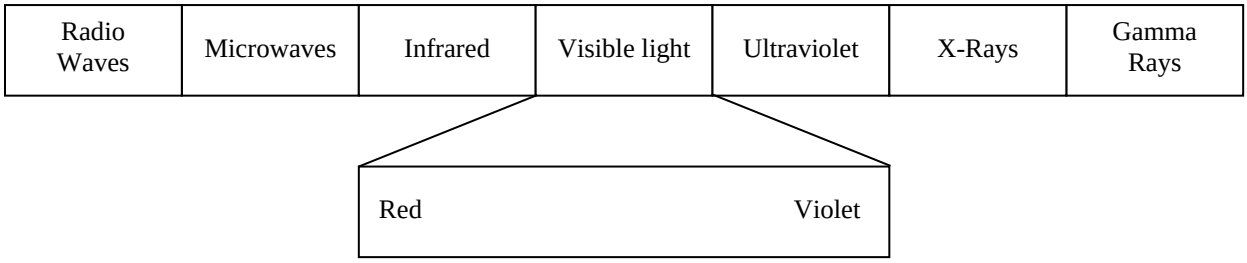
6.3.2 (a) What happens to the electrical supply voltage during the 'Rectifier' stage? (2)
(b) Name the type of components used in the 'Rectifier' stage. (1)

6.3.3 (a) Name the component used in the 'Smoothing' stage. (1)
(b) Draw a sketch graph of voltage versus time at point Z. (2)

27 marks

QUESTION 7 THE ELECTROMAGNETIC SPECTRUM

The diagram below represents the electromagnetic spectrum.



7.1 Name the type of electromagnetic radiation that:

7.1.1 has the longest wavelength. (1)

7.1.2 is used in the treatment of some cancers. (1)

7.1.3 is used to send a signal from the remote control to the TV. (1)

7.2 Valuable items, such as bank notes, can be security marked using fluorescent ink. The ink can only be seen in ultraviolet radiation and is used to differentiate between genuine and counterfeit bank notes.

Explain what happens to make the ink visible when viewed in ultraviolet radiation. (3)

7.3 List two harmful effects of ultraviolet radiation on human skin. (2)

7.4 Below are images taken using X-ray radiation.

[<http://www.ktf-split.hr/>]

[<http://www.horseiq.com/>]

These images reveal bones, flesh and metal pins and plates used to reconstruct broken bones.

Use the images to rank the penetrating ability of X-rays through the three substances (bones, flesh and metal) from highest penetrating ability to lowest penetrating ability. (3)

7.5 7.5.1 A green car is observed in white light.
(a) Which primary colour/s of light is/are reflected?
(b) Which primary colour/s of light is/are absorbed? (3)

7.5.2 A green car is observed in red light.
(a) How does it appear?
(b) Explain your answer. (3)

7.6 **Multiple Choice**
Using capital letters, write the letter of the correct response in your Answer Book.

7.6.1 Which of the following statements is true about yellow paint?

A Yellow paint absorbs blue light
B Yellow paint reflects red light
C Yellow paint reflects green light
D All of the above (2)

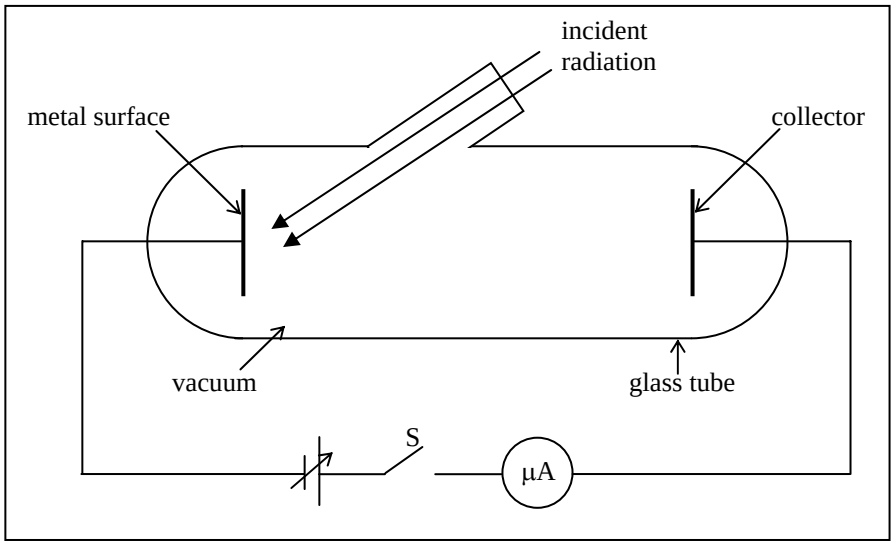
7.6.2 What colour do we see when we mix yellow and magenta paint?

A Red
B Cyan
C Green
D Blue (2)

21 marks

QUESTION 8 THE PHOTOELECTRIC EFFECT

The apparatus shown below was used to investigate the Photoelectric Effect. The apparatus allows for the investigation of several variables. The frequency and intensity of the incident radiation can be changed; the type of metal used at the metal surface can be altered; and the emf supplied across the electrodes can be adjusted.



8.1 Early investigators of this effect found that a zinc plate, when negatively charged, would lose its charge when exposed to ultraviolet light, while a positively charged zinc plate showed no such effect. What could the investigators conclude from these observations? (2)

8.2 A source of bright red light and a source of faint blue light are shone in turn on to the metal surface for the same length of time. In both cases, electrons are ejected from the metal surface.

8.2.1 Name the variables that are being adjusted. (2)

8.2.2 The wavelength of blue light is 440 nm. Calculate the energy of a photon from this source. Express the answer in eV. (6)

8.2.3 The maximum kinetic energy of the electrons ejected by the faint blue light is greater than the maximum kinetic energy of the electrons ejected by the bright red light. Explain why this happens. (6)

8.3 The table below shows the work functions of selected metals.

Metal	**W_f: Work function (eV)**
Caesium	2,14
Sodium	2,75
Copper	4,94
Platinum	5,65

Each of these metals is used in turn at the metal surface. The same light source (of the same frequency and intensity) is shone on each metal plate for the same length of time.

8.3.1 Predict which metal will produce the largest reading on the ammeter. (1)

8.3.2 Give a reason for your answer in 8.3.1. (2)

8.3.3 Calculate the threshold frequency of sodium. (5)

24 marks

QUESTION 9 CELLULAR PHONES

Read the passage below then answer the question that follows.

Are cellular phones a risk to health?

Controversies in Science

The use of cellular phones is a good example of a scientific controversy. Recent research studies have produced tentative evidence that cellphones may have long-term health effects. However, this is by no means certain and the radiation produced by cellphones falls well below safety guidelines.

Would you give up your phone?

How many text messages (sms) do you send a day? Many of us now rely on cellphones for communicating and planning ahead. Parents are a lot happier about young people going off on their own if they know they can phone for help if needed. Would you really wish to give up your phone, even if you knew there was a possibility it might make you unwell?

Who's listening

Cellphone companies in some countries are required to keep records of your calls for up to two years. Police regularly use these records to trace criminals' whereabouts. So do you think they should be able to listen in too?

Some comments from members of society

'Children should be especially careful about cellphone use. Their skulls are still growing so it is easier for radio waves from a cellphone to enter their heads; also, children's cells absorb more radiation than adults.'

'It is cellphone masts that worry me. Cellphone masts give out more microwaves than cellphones. Seven clusters of cancer and other serious illnesses have been discovered around cellphone masts.'

'We must be careful. Even a tiny increase in the risk of brain cancer could cause many more deaths across the world. As brain tumours can take many years to develop we need to monitor the effects over many years.'

'A number of children in my son's class have cellphones and now he wants one. I don't know what to do. I realise the benefits of having a cellphone, but what if the arguments about the links to cancer are true?'

'One Swedish study found no link between using a cellphone and a greater chance of having a tumour. It did show that tumour-suffering cellphone users were twice as likely to have the tumour near their phone ear.'

[<http://www.peep.ac.uk>]

9.1 Considering evidence for and against the use of cellphones, construct a reasoned argument in which you provide an answer to the question:

'Are cellular phones a risk to our health?'

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)

8 marks

Total: 200 marks