GRADE 12

PHYSICAL SCIENCES: PHYSICS Paper 1

TRIALS AUGUST 2008

(150 marks; 3 hours)

This question paper consists of 11 pages and an answer sheet for questions 3.2.2 and 6.1.

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions on the A4 paper provided
2. Non-programmable calculators may be used.
3. Appropriate mathematical instruments may be used.
4. Number the answers correctly according to the numbering system used in this question paper.

Learning outcomes and levels of difficulty

LO1 Practical Scientific Inquiry and Problem Solving Skills
LO2 Constructing and Applying Scientific Knowledge
LO3 The Nature of Science and its relationship to Technology, Society and the Environment

	LO1	LO2	LO3	Level 1	Level 2	Level 3	Level 4
TOTAL %	26	56	18	11	46	22	21
TARGET %	30	50	20	10	50	20	20

QUESTION 1 SKY DIVING

On 16 August 1960, US Air Force Captain Joseph Kittinger entered the record books when he stepped from the gondola of a helium balloon floating at an altitude of 31 330 m and took the longest skydive in history. The air is so thin at this altitude that drag (air-resistance) is negligible. According to Captain Kittinger's 1960 report in *National Geographic*, he was in free fall for 3 900 m. At such extreme altitudes the acceleration due to gravity is 9,72 $m.s^{2}$.

1.1 Show that Captain Kittinger reached a record-breaking speed of 275 $m.s^{-1}$ whilst free-falling for 3 900 m at this high altitude. (3)

1.2 Convert 275 $m.s^{-1}$ to $km.h^{-1}$. (2)

1.3 Calculate the time taken by Kittinger to reach 275 $m.s^{-1}$ (3)

Whilst a few fanatics strive to beat Kittinger's record by jumping from extreme altitudes most skydivers jump from aeroplanes at lower altitudes where there is significant air resistance and much lower terminal velocities are reached.

1.4 Draw a labelled free body diagram to represent the forces acting on a skydiver falling vertically downwards at **terminal velocity**. Represent the skydiver as a small dot ● on your page. (3)

Cindy and Pravesh are part of a sky diving team that performs 'acrobatics' in the air. There are 7 sky divers in the team who jump from the plane one after the other each falling to reach terminal velocity before linking up. Cindy is the first to leave the plane whilst Pravesh is the last. Cindy of mass 64 kg (including her parachute) reaches a terminal velocity of 45 $m.s^{-1}$ and Pravesh of mass 90 kg (including his parachute) who is 120 m vertically above Cindy falls with a terminal velocity of 60 $m.s^{-1}$.

1.5 Consider the forces acting on the bodies and give **TWO** possible reasons why Cindy reached a lower terminal velocity than Pravesh. (4)

1.6 What is the magnitude and direction of the velocity of Pravesh relative to Cindy when they are both falling with terminal velocity? (2)

1.7 How long (in seconds) will it take Pravesh to catch up with Cindy? (2)

Pravesh, falling at 60 $m.s^{-1}$, 'collides' in the air with Cindy, who is falling at 45 $m.s^{-1}$ and they continue to fall together immediately afterwards.

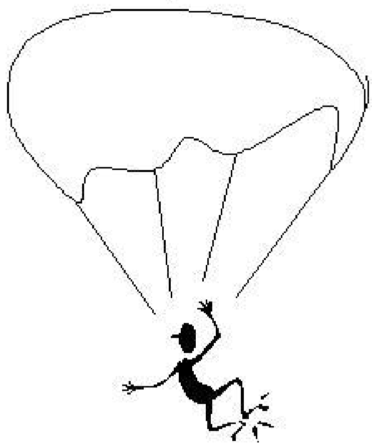
1.8 Calculate the magnitude of the combined velocity of Pravesh and Cindy immediately after they collide. (4)

1.9 If the time over which their velocities changed during the collision was 0,5 s then calculate the magnitude of the force exerted by Pravesh on Cindy. (4)

1.10 Draw a rough velocity time graph to represent the different stages of Cindy's fall. No values need be given but the stages A, B and C (as identified below) must be clearly labelled. (4)

Stage A	From the time she left the plane until she reached terminal velocity for the first time.
Stage B	Falling at terminal velocity before the collision with Pravesh.
Stage C	Collision with Pravesh to reach a new terminal velocity.

Cindy often goes sky diving and she decides to conduct an investigation to determine how the size of her parachute affects the terminal velocity with which she hits the ground when she jumps alone. She selects 4 parachutes with different surface areas and jumps 3 times with each parachute and records her terminal velocity each time upon landing.



1.11 State a suitable hypothesis for her investigation. (1)

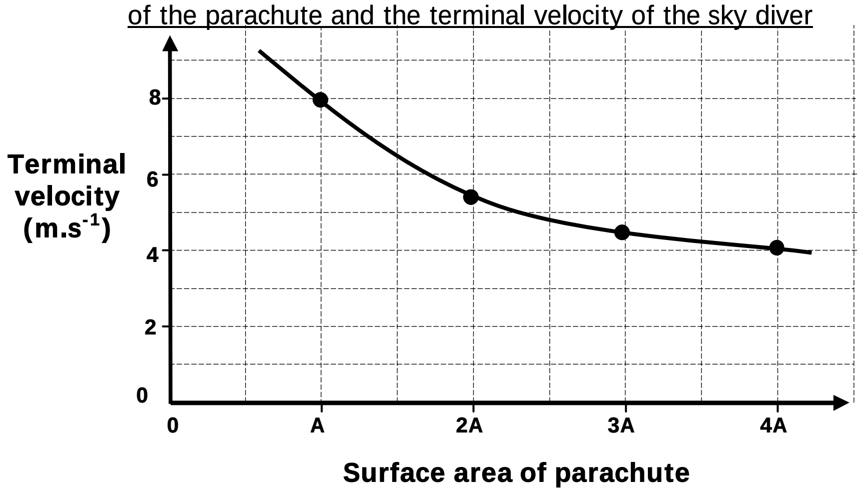
1.12 What is Cindy's independent variable? (1)

1.13 Give 2 variables that Cindy would need to control in this investigation. (2)

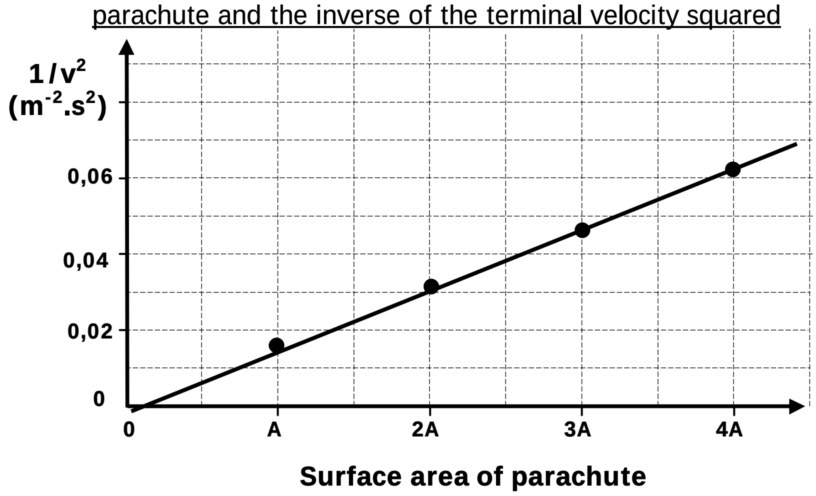
1.14 Why did Cindy jump 3 times with each parachute instead of just once? (2)

The averages of Cindy's results with each parachute are shown in the graphs below

Graph 1 to show the relationship between the surface area of the parachute and the terminal velocity of the sky diver



Graph 2 to show the relationship between the surface area of the parachute and the inverse of the terminal velocity squared



1.15 What do the results indicate about the relationship between the surface area of the parachute and the terminal velocity of the sky diver? (2)

1.16 Explain using principles of physics why Cindy rolls forward on the ground when she lands with the smallest parachute instead of stopping immediately she hits the ground. (3)

42 marks

QUESTION TWO CRIMINAL INVESTIGATION

Whilst in a night club Siya has his car stolen and calls the police. He waits outside the nightclub for the police to arrive. The police car which has its siren on approaches the club and drives past where Siya is standing before parking.

2.1 The siren is emitting a note of frequency 1 200 Hz. but Siya hears a note of frequency 1 100 Hz.

2.1.1 Is the car moving away from Siya or towards him when he hears the note of frequency 1 100 Hz.? (1)

2.1.2 Calculate the magnitude of the velocity of the police car relative to Siya. Take the speed of sound to be 342 $m.s^{-1}$. (4)

Siya tells the policeman that the man he saw inside the nightclub stealing his car keys was wearing a black shirt with red stars on the front. The colour of the lights inside the nightclub was magenta. The policeman reports that his colleague has just caught a man in a speed trap down the road from the club driving Siya's car but this man was wearing a green shirt with yellow stars on the front as seen under a normal white light street lamp.

2.2 Use your knowledge of colour to clearly explain to Siya and the policeman that the criminal had not changed his shirt since leaving the club. (4)

According to the police the criminal was travelling at 40 $m.s^{-1}$ when he passed their speed trap. They flagged him down and he braked uniformly coming to rest in a distance of 240 m. The mass of the car was 1 200 kg.

2.3 Calculate the kinetic energy of the car as it passed the speed trap. (3)

2.4 State the work-energy theorem. (2)

2.5 Use the work-energy theorem to calculate the resultant force exerted by the brakes in bringing the car to rest. (3)

2.6 Calculate the power of the cars braking system. (5)

22 marks

QUESTION THREE ELECTROMAGNETIC WAVES

The table below represent the regions of the electromagnetic spectrum in order of decreasing wavelength.

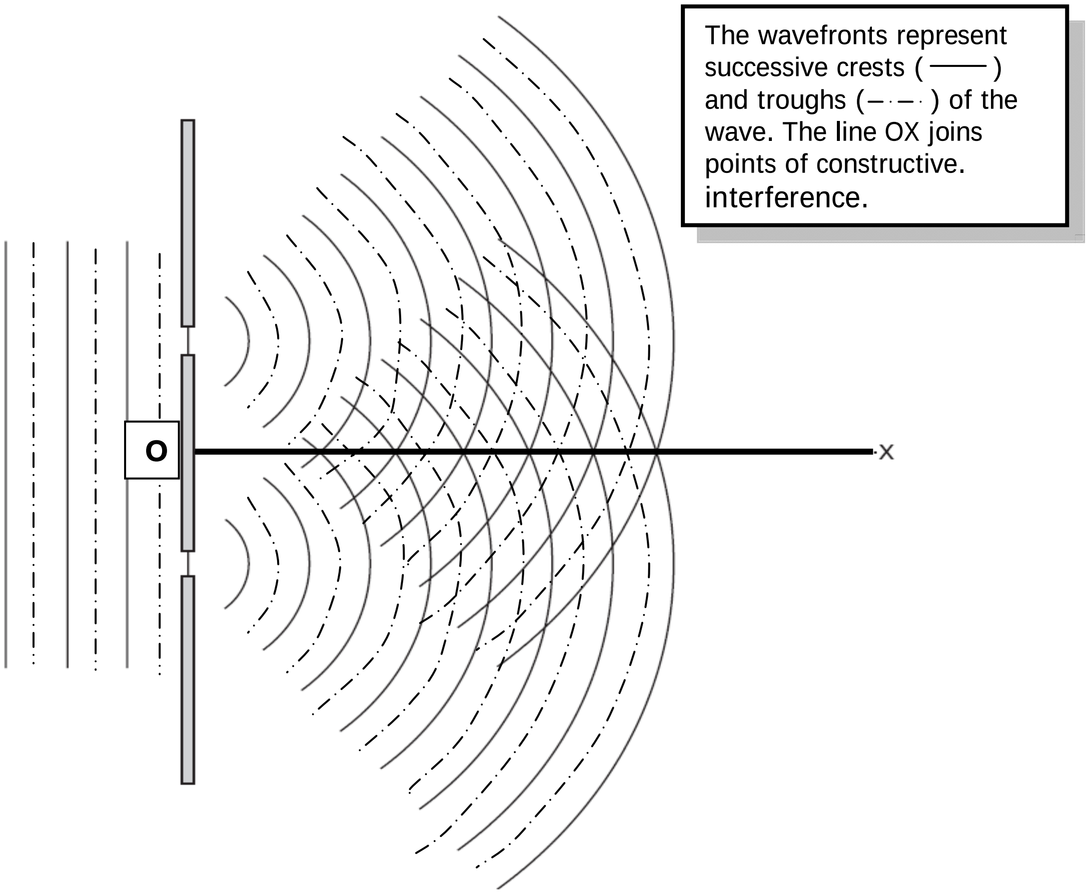
Radio waves	Microwaves	Infra-red	Visible light	Ultra violet	X-rays	Gamma rays

3.1 Knowledge of electromagnetic waves and their properties has benefited mankind in many ways. Name the waves that are used in

3.1.1 security checks at airports (1)

3.1.2 optical communication fibres and remote controls (1)

3.2 The diagram below shows wavefronts of **red light** incident on, and emerging from, a double slit arrangement. Each of the slits acts as a **coherent** light source.



3.2.1 In which region of the electromagnetic spectrum would you find red light? (1)

3.2.2 On the diagram **on the answer sheet**, draw a line to show

(i) a second region along which constructive interference may be observed (label this line CC),

(ii) a region along which destructive interference may be observed (label this line DD). (2)

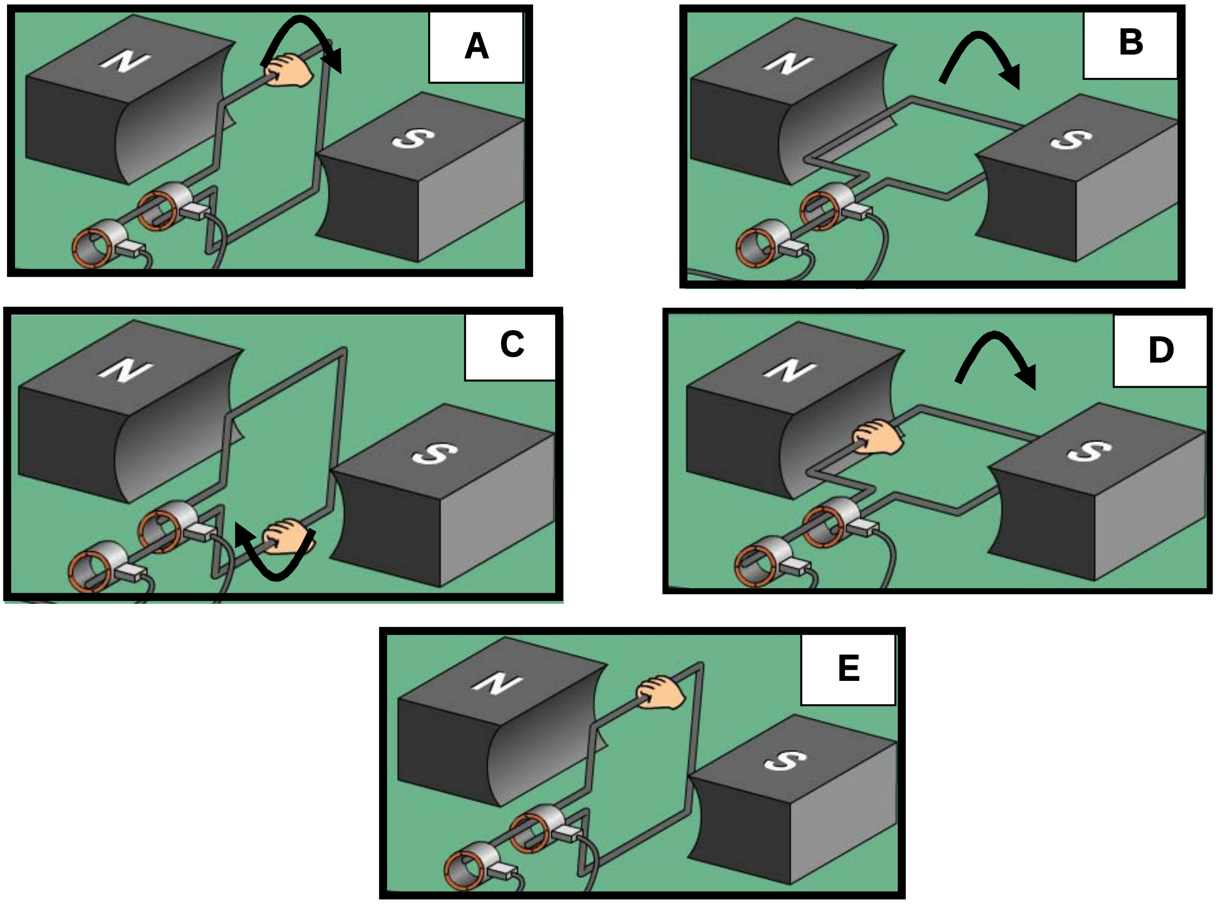
3.2.3 If a screen were placed at X perpendicular to the line OX, describe what would be seen on the screen. (2)

3.2.4 If blue light were used instead of red light, how would the pattern differ? (1)

8 marks

QUESTION FOUR GENERATOR

The diagrams below show 5 positions in the clockwise rotation of the coil of a simple generator.



4.1 What is the energy conversion taking place in this generator? (1)

4.2 Use Fleming's Right Hand Dynamo Rule to determine the direction of the induced current in the coil in position **B**. Give your answer as either *clockwise or anticlockwise*. (1)

4.3 Draw a sketch graph of emf vs. time for one full rotation of the coil. Clearly mark positions A to E on your graph. (4)

John has made a simple generator similar to that shown in the sketch and he decides to investigate the factors that influence the size of the induced emf.

4.4 Give **2** different variables that he could investigate and state how he should change each of them in order to **increase** the induced emf. (4)

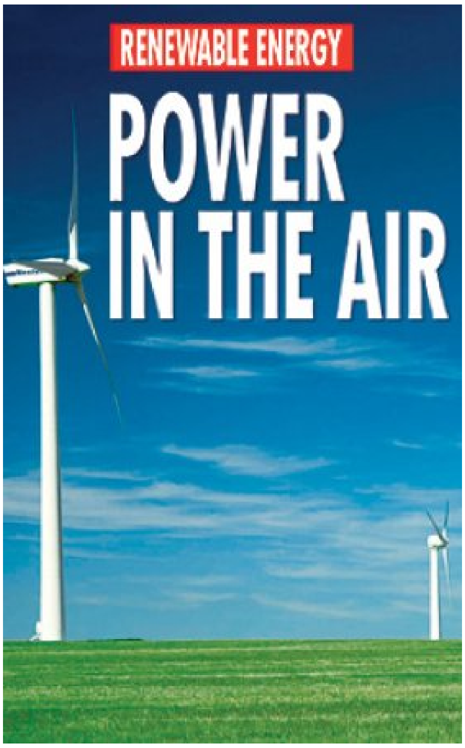
10 marks

QUESTION FIVE WIND POWER

5.1 Read the article on renewable energy before answering the questions that follow.

RENEWABLE ENERGY Eskom blowing hotter on large-scale wind-energy prospects

By: Esmarie Swanepoel Published: 13 Dec 07 - 17:00



Cost vs. Environment

State power utility Eskom is often criticised for its seeming unwillingness to embrace alternative and renewable energy platforms in seeking ways to align its production with fast-increasing demand. But Eskom insists that it is taking renewable energy into account, stressing that its planning has to strike a balance between the operating costs of such technology, as well as its ability to operate on demand. Environmentalists view wind power as a renewable and clean technology to generate power, but the high cost of generating electricity by using wind technology is still standing in the way of the technology being used on a larger scale.

Future plans

In fact, Eskom has approved plans for a 100-MW wind power plant, construction of which could start in 2009. The development, to take place in the Western Cape Province, is proposed to comprise a cluster of up to 100 wind turbines to be constructed over an area of 25 km^2.

Location of suitable wind farm sites

Research shows that weather conditions are critically important when considering the location of wind turbines and identifying wind-farm sites. In 2002 Eskom erected three wind turbines at an experimental wind energy farm at Klipheuwel on the West Coast. This site was chosen because of the acceptable wind speeds, its proximity to Cape Town for research and demonstration purposes and an existing electricity distribution infrastructure (easy access to the National Grid).

Cost and space

Variation in the speed and availability of the wind can restrict continuous operations. The cost and space required for a wind-operated power plant is still relatively high – for instance, Eskom estimates that a 300 km^2 area of wind machines would be necessary to produce the same power generated by one large coal-fired or nuclear power station. It is estimated that, in South Africa, wind energy will cost 3 times more than energy produced by Eskom's existing coal-based power stations.

(Adapted from http://www.engineeringnews.co.za/article.php?a_id=123647)

5.1.1 What do you understand by the terms '**renewable'** and **'clean'** when applied to wind power technology? *(Paragraph 1.)* (2)

5.1.2 Why is Klipheuwel on the Western Coast of South Africa a suitable site for a wind energy farm? (3)

The following extract is taken from an advert found on the *'tiscover'* travel website:

> **Klipheuwel Cottage** Self-Catering Farm accommodation
> This self-catering farmstay is a little cottage surrounded by tranquil vineyards and mountains.

5.1.3 Give two objections that the residents of Klipheuwel may have to the construction of a wind farm near their homes? (2)

5.1.4 Explain what you understand by the opening sentence of the last paragraph
"Variation in the speed and availability of the wind can restrict continuous operations." (2)

5.1.5 What impact does the generation of electricity from coal have on environmental health? (2)

5.1.6 Express your opinion on whether or not economic factors should override environmental concerns with respect to electricity production. (4)

[15]

5.2 The amount of energy a wind turbine can harness depends on both the wind speed and the length of the rotor blade. Wind speeds below about 13 $km.h^{-1}$ are insufficient to produce power, while powerful gusts can damage mechanical equipment. The following results were recorded during an experiment to test the effect of wind speed and blade surface area on electricity generation by a wind turbine.

Blade surface area (m^2)	Current (A) generated at wind speed			
	2 $m.s^{-1}$	6 $m.s^{-1}$	10$m.s^{-1}$	12 $m.s^{-1}$
0,8	0,001	0,020	0,130	0,230
3,1	0,004	0,100	0,530	0,920
7,1	0,009	0,260	1,200	2,100
12,6	0,020	0,460	2,100	3,700
19,6	0,030	0,700	3,400	5,800

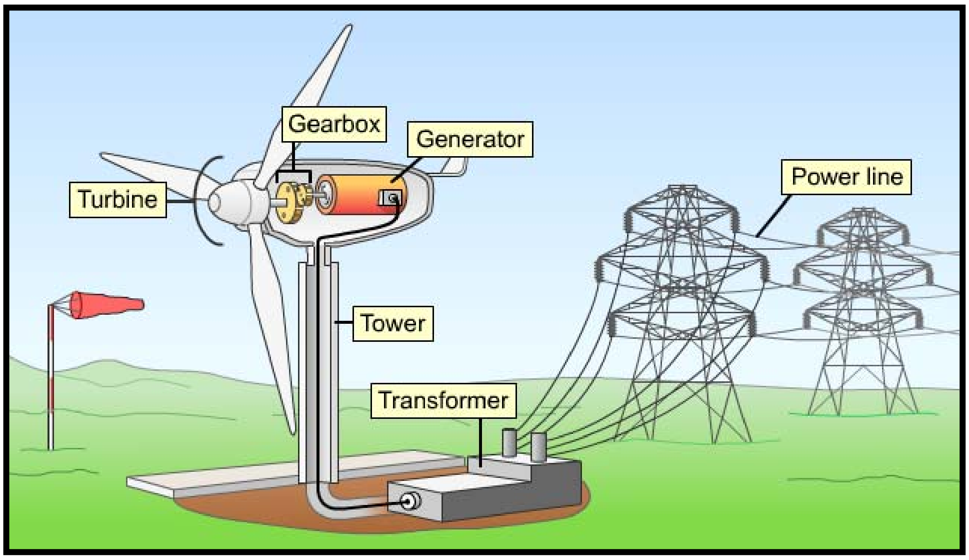
5.2.1 Analyse the results in the above table and draw conclusions regarding the effect of blade area and wind speed on power production by a wind generator. (2)

5.2.2 Which of these factors has the **greatest** effect on the size of the current generated? Use figures from the table to support your answer. (3)

5.2.3 You have been given the task of investigating how further changes to the blades may affect power production. Give **one** change that you could make to the blades (whilst keeping the surface area constant) and give a **hypothesis** as to how you think it would affect power production. (3)

[8]

5.3 Consider the diagram of a wind turbine below. *(Courtesy of Plato Learning.)*



5.3.1 What type of transformer (*step-up or step-down)* is needed to change the voltage produced by the wind turbine for transmission in the power lines? (1)

5.3.2 Explain why the transformer given in answer to 5.3.1 is needed. (2)

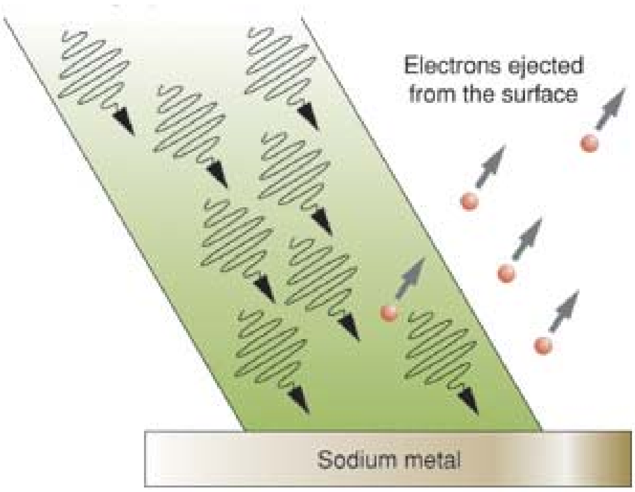
5.3.3 Eskom wind generators produce alternating current (AC). Explain why this is essential for the operation of the transformer. (2)

[5]

28 marks

QUESTION SIX PHOTOELECTRIC EFFECT

Electromagnetic radiation of varying frequency is shone onto a piece of sodium metal.



The table below shows how the maximum kinetic energy (Ek) of a photoelectron from the sodium metal varies with the frequency (f) of the electromagnetic (EM) radiation.

Frequency of EM waves (in 10^{14} Hz)	**Maximum kinetic energy of photoelectron (in eV)**
6,6	0,4
8,2	1,0
9,2	1,3
10,6	2,0
12,0	2,4

6.1 Use the graph paper on your **answer sheet** to plot a graph to show the relationship between the frequency of the EM waves (x-axis) and the maximum kinetic energy of the photoelectrons (y-axis). Extrapolate the graph back to cut the x-axis. Both axes must start at zero. (6)

6.2 What is the minimum frequency (in Hz) of the EM radiation that would just be able to eject an electron from the sodium metal? (1)

6.3 What name is given to this frequency? (1)

6.4 What is meant by the **work function** of a metal? (2)

6.5 Calculate the work function of sodium metal. (3)

In a new experiment electromagnetic waves with a frequency of 9,8 x 10^{14} Hz are shone onto a piece of sodium metal and the intensity of the waves is gradually increased.

6.6 How will increasing the intensity of the waves effect:

6.6.1 The maximum kinetic energy of the photoelectrons emitted from the sodium metal? *(increase, decrease or no effect)*

6.6.2 The number of photoelectrons emitted from the sodium metal? *(increase, decrease or no effect)* (2)

6.7 Explain your answers to 6.6.1 and 6.6.2 in terms of the particle nature of light. (5)

20 marks

QUESTION SEVEN **SHEDDING NEW LIGHT**

Read the following extract adapted from Popular Mechanics, May 2008

Shedding New Light - Super-efficient LEDs and CFLs are outshining Edison's glowing filament.

1 Incandescent Light Bulb

More than a century after Thomas Edison created a practical incandescent light bulb we're still stuck with the same basic inefficient design. What we see is actually just a side-effect of the white hot tungsten filament as little as 5% of the energy consumed is converted to light. The rest is dissipated (given off) as heat.

2 Compact Fluorescent Light (CFL)

CFLs are simply fluorescent tubes folded back on themselves. On average they last 12 times longer than ordinary incandescent bulbs and consume one fifth the electricity. *(CFLs are what are commonly marketed as 'energy saver' bulbs.)* Mercury vapour inside the fluorescent tube, ionised by an electric current discharges UV light. The UV radiation causes phophors coating the inside of the tube to glow (fluoresce). Unfortunately the mercury content makes these bulbs hard to dispose of safely. *(Mercury is poisonous and accumulates in the food chain since it is not biodegradable.)*

3 Light-Emitting Diode (LED)

Construction of today's LEDs starts with a semi-conducting material such as silicon which is selectively doped with impurities to produce p- and n-type material which is joined to form p-n junctions. As charge carriers flow into the p-n junction electrons emit energy. The substance the LED is made of determines its colour. Since the 1990s the development of blue types has given rise to white light capability.

4 Photon phenomenon

An average 100 watt incandescent bulb has a light output of about 15 lumens per watt and lasts 1 year. *(A lumen is a measure of light intensity.)* White power LEDs emit over 80 lumens per watt. Throw in long life and low power consumption and you're looking at a lighting phenomenon. Leading LED developer and manufacturer Cree calls its LR6 *'the longest-lasting, most energy-efficient downlight ever made.'* It will last more than 20 years in normal use.

5 Reducing our environmental footprint

According to the Department of Energy, in the next 20 years rapid adoption of LED lighting in the US can;

- reduce electricity demands from lighting by 62%
- eliminate 258 metric tonnes of carbon dioxide emissions
- avoid building 133 new power plants
- save around R1 trillion

Incandescent Light Bulb

Compact Fluorescent Light (CFL)

Bulb containing Light-Emitting Diodes (LEDs)

7.1 Give **two** advantages of CFLs over normal incandescent light bulbs. (2)

7.2 Why is it not advisable to dispose of CFLs in landfill sites? *(Paragraph 2)* (2)

7.3 Give **one** example of a suitable 'impurity' with which silicon can be doped to produce a p-type material. *(Paragraph 3)* (1)

7.4 Consider the statement made by leading LED developer and manufacturer Cree about its latest LED called LR6; *'the longest-lasting, most energy-efficient downlight ever made.'*
Give **two** statistics (facts and figures) that back up this claim. *(Paragraph 4)* (2)

7.5 Consider the 4 claims made by the Department of Energy in the last paragraph and explain how the use of LEDs can bring about each of the changes mentioned. (4)

7.6 You have been given an LED and want to conduct an investigation to test various properties associated with it. The manufacturers claim that the LED operates best when the potential difference across it is 2,4 V and the current though it is 15 mA. You have the following apparatus:

- LED (2,4 V ; 15 mA)
- Battery (9 V)
- Voltmeter
- Ammeter
- Rheostat
- Connecting leads

7.6.1 You need to measure the current through the LED and the potential difference across the LED. The rheostat must be connected in series with the LED in order to protect it from currents in excess of 15 mA. Draw a circuit diagram to show how these components must be connected. (3)

7.6.2 Calculate the resistance of the rheostat required to ensure that the LED operates at the optimum voltage and current (2,4 V; 15 mA) when connected in the above circuit using the 9 V battery. (4)

7.6.3 Calculate the power output of the LED when connected correctly according to the given specifications. (2)

[9]

20 marks

TOTAL: 150 marks