basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

**NATIONAL
SENIOR CERTIFICATE**

GRADE 12

PHYSICAL SCIENCES: PHYSICS (P1)

NOVEMBER 2014

MARKS: 150

TIME: 3 hours

This question paper consists of 18 pages, 3 data sheets and 1 graph sheet.

INSTRUCTIONS AND INFORMATION

1. Write your centre number and examination number in the appropriate spaces in the ANSWER BOOK and on the GRAPH PAPER.

2. This question paper consists of TEN questions. Answer ALL the questions in the ANSWER BOOK.

3. Start EACH question on a NEW page in the ANSWER BOOK.

4. Number the answers correctly according to the numbering system used in this question paper.

5. Leave ONE line between two subsections, for example between QUESTION 2.1 and QUESTION 2.2.

6. You may use a non-programmable calculator.

7. You may use appropriate mathematical instruments.

8. You are advised to use the attached DATA SHEETS.

9. Show ALL formulae and substitutions in ALL calculations.

10. Round off your final numerical answers to a minimum of TWO decimal places.

11. Give brief motivations, discussions, et cetera where required.

12. Write neatly and legibly.

QUESTION 1: MULTIPLE-CHOICE QUESTIONS

Four options are provided as possible answers to the following questions. Each question has only ONE correct answer. Write only the letter (A–D) next to the question number (1.1–1.10) in the ANSWER BOOK, for example 1.11 D.

1.1   Which ONE of the following physical quantities is a measure of the inertia of a body?

      A   Mass

      B   Energy

      C   Velocity

      D   Acceleration   (2)

1.2   The magnitude of the gravitational force exerted by one body on another body is **F**. When the distance between the centres of the two bodies is doubled, the magnitude of the gravitational force, in terms of **F**, will now be …

      A $\frac{1}{4}\boldsymbol{F}$

      B $\frac{1}{2}\boldsymbol{F}$

      C   2**F**

      D   4**F**   (2)

1.3   An object is thrown vertically upwards. Which ONE of the following regarding the object's velocity and acceleration at the highest point of its motion is CORRECT? Ignore the effects of friction.

	VELOCITY	ACCELERATION
A	Zero	Zero
B	Zero	Upwards
C	Maximum	Zero
D	Zero	Downwards

(2)

1.4   An object of mass *m* moving at velocity *v* collides head-on with an object of mass 2*m* moving in the opposite direction at velocity *v*. Immediately after the collision the smaller mass moves at velocity *v* in the opposite direction and the larger mass is brought to rest. Refer to the diagram below.

BEFORE COLLISION   **AFTER COLLISION**
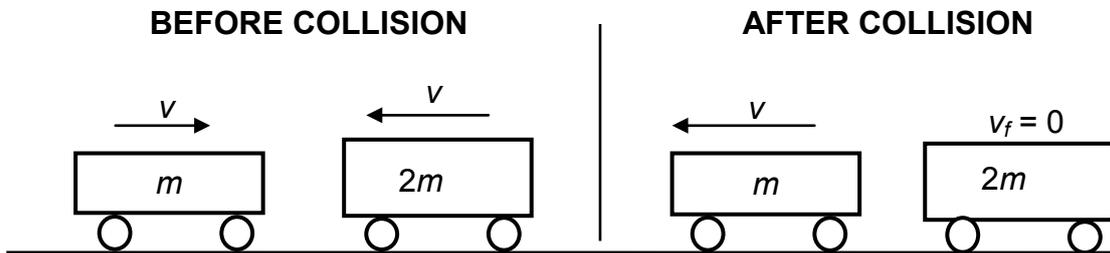
Ignore the effects of friction.

Which ONE of the following is CORRECT?

|	MOMENTUM	MECHANICAL ENERGY
A	Conserved	Conserved
B	Not conserved	Conserved
C	Conserved	Not conserved
D	Not conserved	Not conserved

(2)

1.5   Two balls, **P** and **Q**, are dropped simultaneously from the same height. Ball **P** has TWICE the mass of ball **Q**. Ignore the effects of air friction.

Just before the balls hit the ground, the kinetic energy of ball **P** is *x*. The kinetic energy of ball **Q**, in terms of *x*, will be …

A $\frac{1}{4}x$

B $\frac{1}{2}x$

C   *x*

D   2*x*   (2)

1.6   The diagram below shows the electron transitions **P**, **Q**, **R** and **S** between different energy levels in an atom.
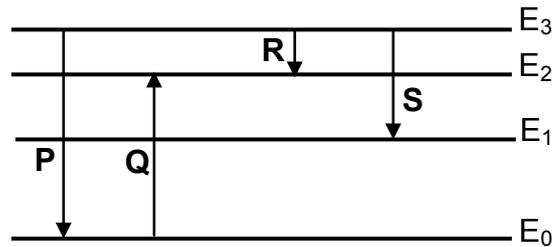
Which ONE of the transitions will result in an emission of a radiation with the longest wavelength?

A   **P**

B   **Q**

C   **R**

D   **S**   (2)

1.7   Two charges of + 2 nC and - 2 nC are located on a straight line. **S** and **T** are two points that lie on the same straight line as shown in the diagram below.
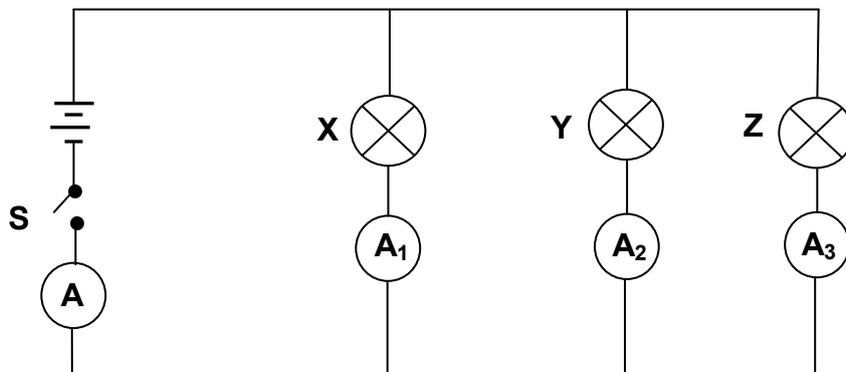

Which ONE of the following correctly represents the directions of the RESULTANT electric fields at **S** and at **T**?

	DIRECTION OF THE RESULTANT ELECTRIC FIELD AT POINT S	DIRECTION OF THE RESULTANT ELECTRIC FIELD AT POINT T
A	Right	Left
B	Left	Left
C	Right	Right
D	Left	Right

(2)

1.8   Three light bulbs, **X**, **Y** and **Z** with resistances R, $2R$ and R respectively, are connected in a circuit as shown below. The battery has negligible internal resistance.

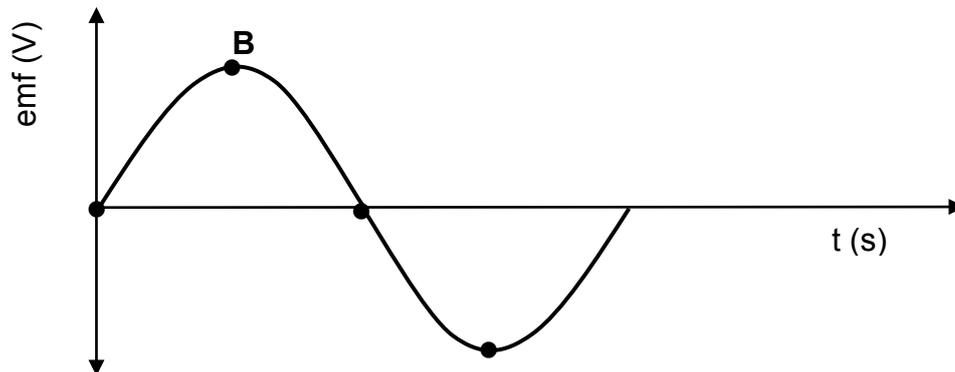When switch **S is closed**, all the bulbs light up. The reading on ammeter **A** is 2,5 A.

Which ONE of the following correctly describes the readings on the ammeters (in amperes) when bulb **Z** burns out?

	A₁	**A₂**	**A₃**	**A**
A	1,25	1,25	0	2,5
B	1,6	0,8	0,1	2,5
C	0,75	0,75	0	1,5
D	1	0,5	0	1,5

(2)

1.9   The coils of an AC generator make one complete rotation. The resulting graph
        for the output emf is shown below.

        The position **B** on the graph is obtained when the plane of the coil is at an
        angle of … to the magnetic field.

        A   0º

        B   60º

        C   90º

        D   120º   (2)

1.10   A learner makes the observations below after conducting an experiment using
        a photocell with frequencies of the incident light being above the threshold
        frequency (cut-off frequency).

        (i)   The photocurrent increases as the intensity of the incident light
                increases.

        (ii)   The ammeter in the circuit registers a current immediately after the
                incident light is radiated on the cathode.

        (iii)   The photocurrent increases as the frequency of the incident light
   increases.

        Which of the observation(s) is/are CORRECT?

        A   (i) only

        B   (ii) only

        C   (i) and (ii) only

        D   (ii) and (iii) only   (2)
                                                                                              [20]

QUESTION 2   (Start on a new page.)

Two blocks of masses 20 kg and 5 kg respectively are connected by a light inextensible string, **P**. A second light inextensible string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley. A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T_1 and T_2 respectively. Ignore the effects of air friction.

250 N ←

T_2 **Q**

5 kg

T_1 **P**

20 kg
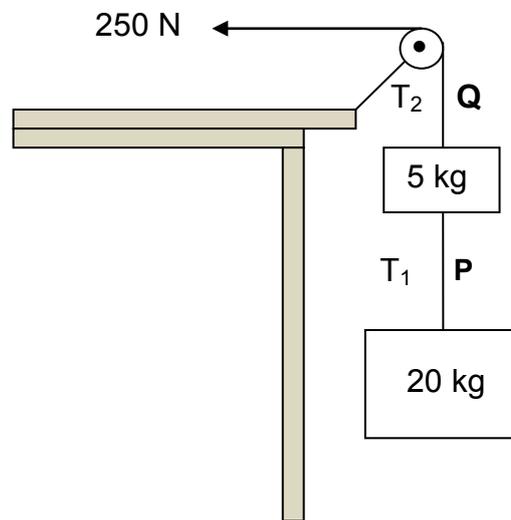
|		
2.1	State Newton's Second Law of Motion in words.	(2)
2.2	Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**.	(3)
2.3	Calculate the magnitude of the tension T_1 in string **P**.	(6)
2.4	When the 250 N force is replaced by a sharp pull on the string, one of the two strings break.	
	Which ONE of the two strings, **P** or **Q**, will break?	(1)

[12]

QUESTION 3   (Start on a new page.)

A ball, **A**, is thrown vertically upward from a height, h, with a speed of 15 m·s^{-1}. AT THE SAME INSTANT, a second identical ball, **B**, is dropped from the same height as ball **A** as shown in the diagram below.

Both balls undergo free fall and eventually hit the ground.
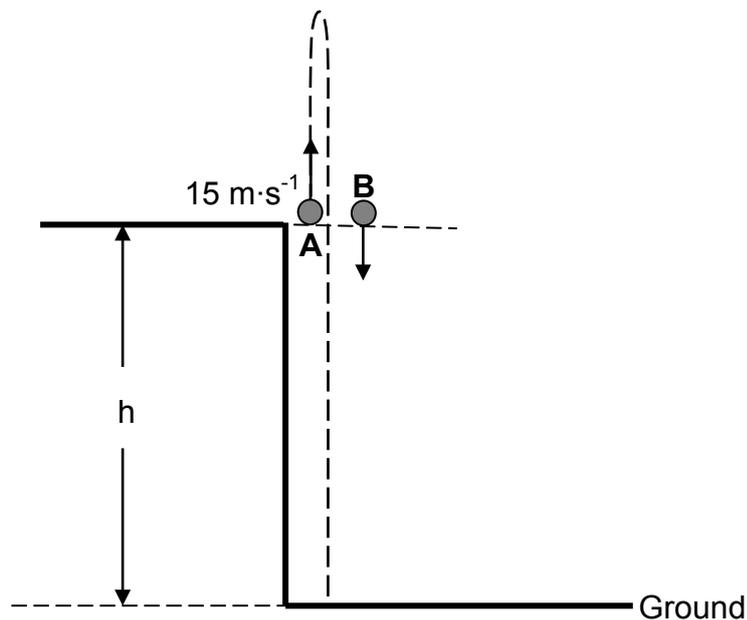
3.1　　Explain the term *free fall.*　　　　　　　　　　　　　　　　　　(2)

3.2　　Calculate the time it takes for ball **A** to return to its starting point.　　(4)

3.3　　Calculate the distance between ball **A** and ball **B** when ball **A** is at its maximum height.　　　　　　　　　　　　　　　　　　　　　　　(7)

3.4　　Sketch a velocity-time graph in the ANSWER BOOK for the motion of ball **A** from the time it is projected until it hits the ground.

　　　　Clearly show the following on your graph:

- The initial velocity
- The time it takes to reach its maximum height
- The time it takes to return to its starting point　　　　　(4)

[17]

QUESTION 4   (Start on a new page.)

Dancers have to learn many skills, including how to land correctly. A dancer of mass 50 kg leaps into the air and lands feet first on the ground. She lands on the ground with a velocity of 5 m·s^{-1}. As she lands, she bends her knees and comes to a complete stop in 0,2 seconds.

4.1	Calculate the momentum with which the dancer reaches the ground.	(3)
4.2	Define the term *impulse* of a force.	(2)
4.3	Calculate the magnitude of the net force acting on the dancer as she lands.	(3)

Assume that the dancer performs the same jump as before but lands without bending her knees.

|		
4.4	Will the force now be GREATER THAN, SMALLER THAN or EQUAL TO the force calculated in QUESTION 4.3?	(1)
4.5	Give a reason for the answer to QUESTION 4.4.	(3)

[12]

QUESTION 5   (Start on a new page.)

5.1 The diagram below shows a track, **ABC**. The curved section, **AB**, is frictionless. The rough horizontal section, **BC**, is 8 m long.
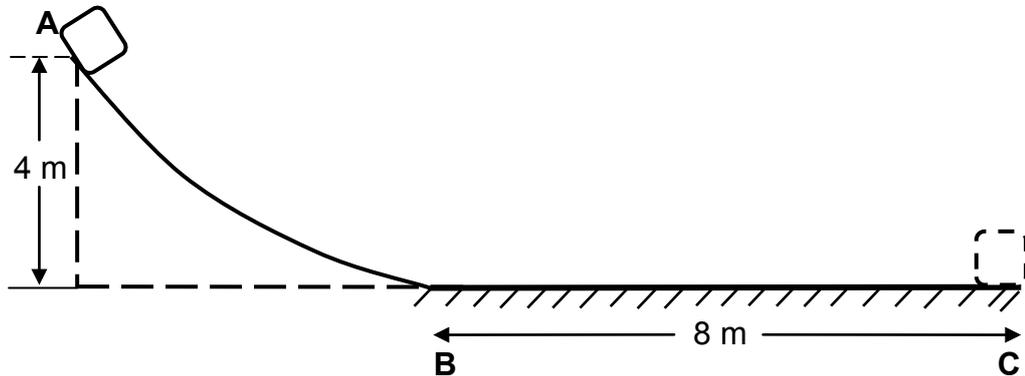
An object of mass 10 kg is released from point **A** which is 4 m above the ground. It slides down the track and comes to rest at point **C**.

5.1.1 State the *principle of conservation of mechanical energy* in words. (2)

5.1.2 Is mechanical energy conserved as the object slides from **A** to **C**? Write only YES or NO. (1)

5.1.3 Using ENERGY PRINCIPLES only, calculate the magnitude of the frictional force exerted on the object as it moves along **BC**. (6)

5.2 A motor pulls a crate of mass 300 kg with a constant force by means of a light inextensible rope running over a light frictionless pulley as shown below. The coefficient of kinetic friction between the crate and the surface of the inclined plane is 0,19.
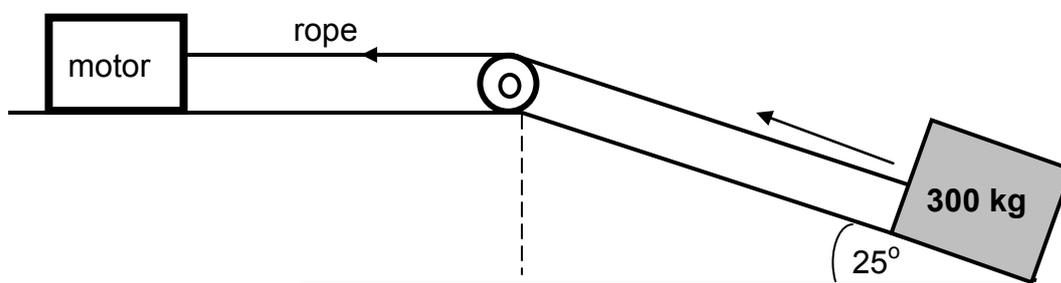
5.2.1 Calculate the magnitude of the frictional force acting between the crate and the surface of the inclined plane. (3)

The crate moves up the incline at a constant speed of 0,5 m·s^{-1}.

5.2.2 Calculate the average power delivered by the motor while pulling the crate up the incline. (6)

[18]

QUESTION 6   (Start on a new page.)

6.1   The siren of a stationary ambulance emits a note of frequency 1 130 Hz. When the ambulance moves at a constant speed, a stationary observer detects a frequency that is 70 Hz **higher** than that emitted by the siren.

   6.1.1   State the Doppler effect in words.   (2)

   6.1.2   Is the ambulance moving *towards* or *away from* the observer? Give a reason for the answer.   (2)

   6.1.3   Calculate the speed at which the ambulance is travelling. Take the speed of sound in air as 343 m·s^{-1}.   (5)

6.2   A study of spectral lines obtained from various stars can provide valuable information about the movement of the stars.

   The two diagrams below represent different spectral lines of an element. Diagram **1** represents the spectrum of the element in a laboratory on Earth. Diagram **2** represents the spectrum of the same element from a distant star.
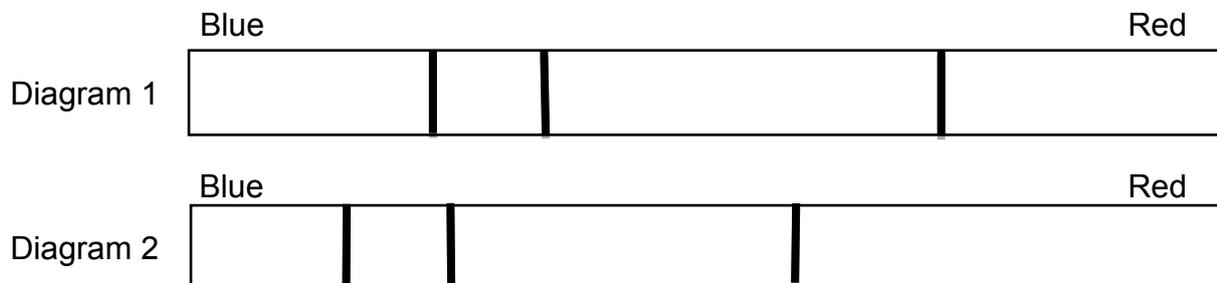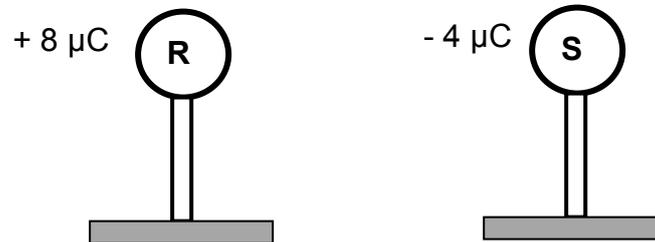

   Is the star moving *towards* or *away from* the Earth? Explain the answer by referring to the shifts in the spectral lines in the two diagrams above.   (2)

                                                                           [11]

QUESTION 7   (Start on a new page.)

The diagram below shows two small identical metal spheres, **R** and **S**, each placed on a wooden stand. Spheres **R** and **S** carry charges of + 8 µC and - 4 µC respectively. Ignore the effects of air.

+ 8 µC **R**   - 4 µC **S**

7.1   Explain why the spheres were placed on wooden stands.   (1)

Spheres **R** and **S** are brought into contact for a while and then separated by a small distance.

7.2   Calculate the net charge on each of the spheres.   (2)

7.3   Draw the electric field pattern due to the two spheres **R** and **S**.   (3)

After **R** and **S** have been in contact and separated, a third sphere, **T**, of charge + 1 µC is now placed between them as shown in the diagram below.

←——— 10 cm ———→←——————— 20 cm ——————→

R   **T**   **S**
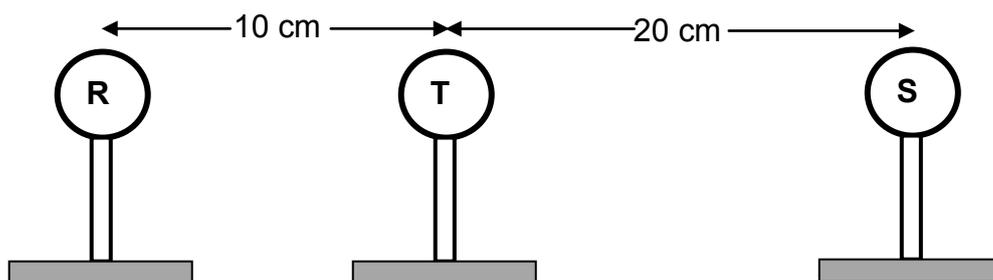
7.4   Draw a free-body diagram showing the electrostatic forces experienced by sphere **T** due to spheres **R** and **S**.   (2)

7.5   Calculate the net electrostatic force experienced by **T** due to **R** and **S**.   (6)

7.6   Define the *electric field at a point*.   (2)

7.7   Calculate the magnitude of the net electric field at the location of **T** due to **R** and **S**. (Treat the spheres as if they were point charges.)   (3)

[19]

QUESTION 8   (Start on a new page.)

NOTE: The graph for QUESTION 8.1.2 must be drawn on the GRAPH SHEET attached at the end of the QUESTION PAPER.

8.1   A group of learners conduct an experiment to determine the emf (ε) and internal resistance (r) of a battery. They connect a battery to a rheostat (variable resistor), a low-resistance ammeter and a high-resistance voltmeter as shown in the diagram below.
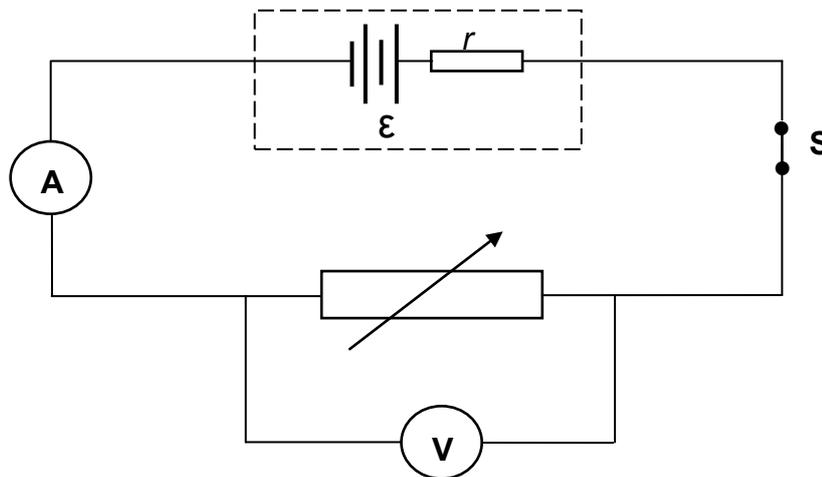
The data obtained from the experiment is displayed in the table below.

READING ON VOLTMETER (V)	READING ON AMMETER (A)
2	0,58
3	0,46
4	0,36
5	0,24
6	0,14

8.1.1   State ONE factor which must be kept constant during the experiment.   (1)

8.1.2   Using the information in the table above, plot the points and draw the line of best fit on the attached GRAPH SHEET.   (3)

Use the graph drawn in QUESTION 8.1.2 to determine the following:

8.1.3   Emf (ε) of the battery   (1)

8.1.4   Internal resistance of the battery, WITHOUT USING ANY FORM OF THE EQUATION $\varepsilon = I(R + r)$ (3)

8.2   Three electrical devices, **X**, **Y** and **Z**, are connected to a 24 V battery with internal resistance r as shown in the circuit diagram below. The power rating of each of the devices **X** and **Y** are indicated in the diagram.
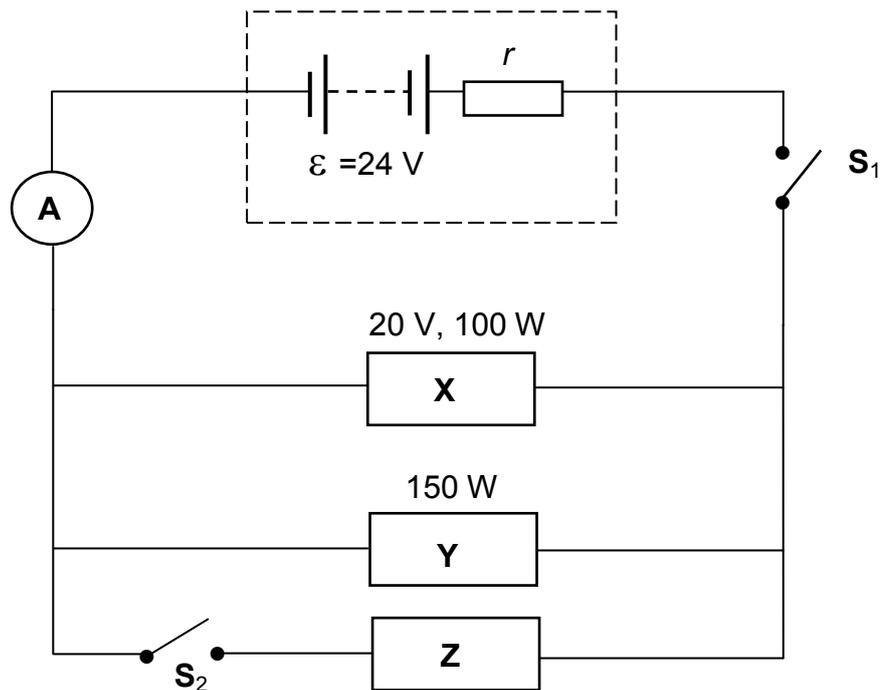
With switch **S$_1$** closed and **S$_2$** open, the devices function as rated.

Calculate the:

8.2.1   Current in **X**   (3)

8.2.2   Resistance of **Y**   (3)

8.2.3   Internal resistance of the battery   (5)

Now switch **S$_2$** is also closed.

8.2.4   Identify device **Z** which, when placed in the position shown, can still enable **X** and **Y** to operate as rated. Assume that the resistances of all the devices remain unchanged.   (1)

8.2.5   Explain how you arrived at the answer to QUESTION 8.2.4.   (2)
                                                                                                        [22]
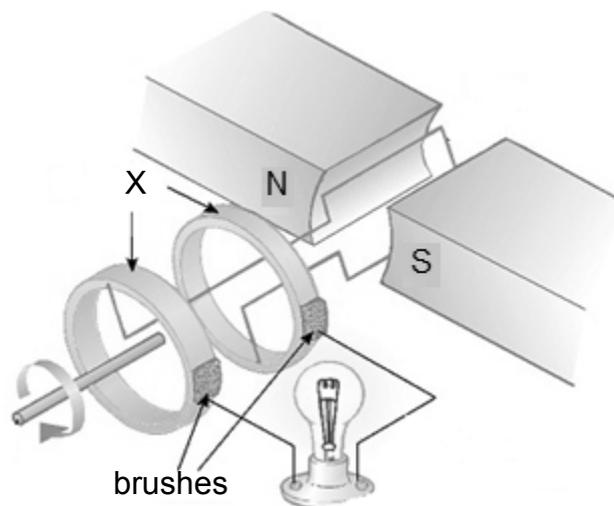
QUESTION 9   (Start on a new page.)

The diagram below represents a simplified version of an electrical machine used to light up a bulb.
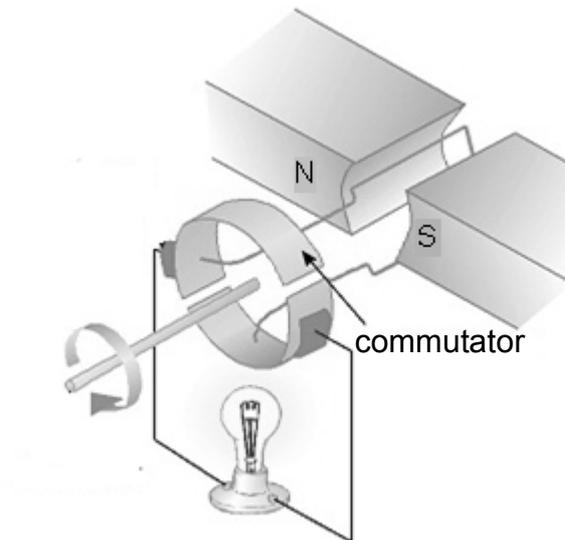
9.1   Name the principle on which the machine operates.   (1)
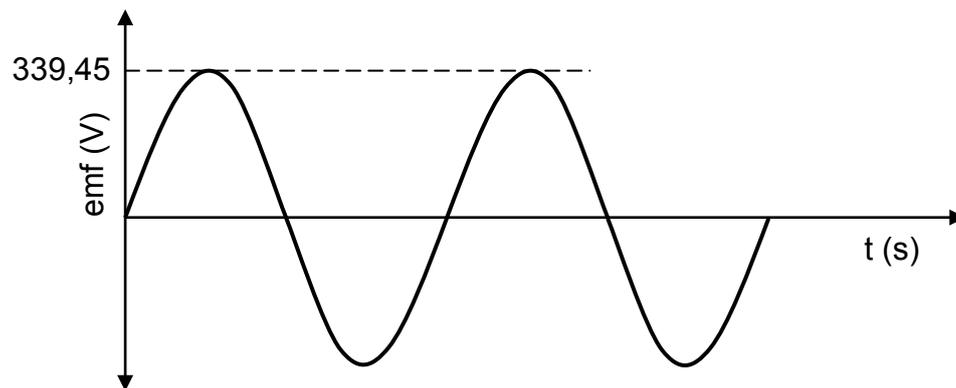
9.2   State ONE way in which to make this bulb burn brighter.   (1)

Some changes have been made to the machine and a new device is obtained as shown below.

9.3   Name part **X** in the new device.   (1)
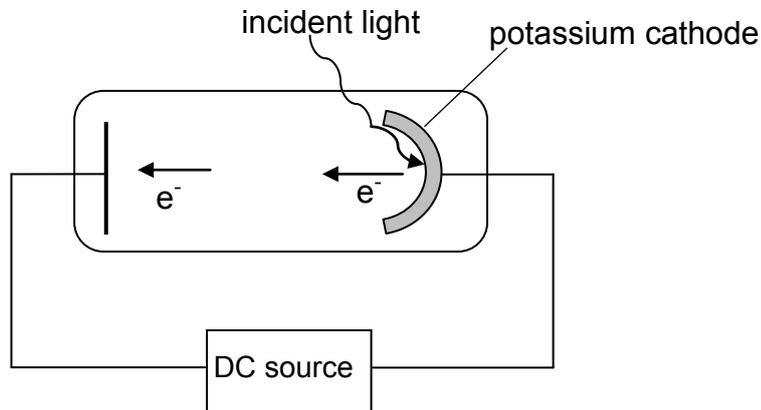
9.4   The graph of output emf versus time obtained using the device in
        QUESTION 9.3 is shown below.

9.4.1   Define the term *root mean square value* of an AC voltage.   (2)

9.4.2   Calculate the rms voltage.   (3)

                                                                            [8]

QUESTION 10 (Start on a new page.)

Ultraviolet light is incident onto a photocell with a potassium cathode as shown below. The threshold frequency of potassium is 5,548 x 10^{14} Hz.

10.1   Define the term *threshold frequency (cut-off frequency)*.   (2)

The maximum speed of an ejected photoelectron is 5,33 x 10^5 m·s^{-1}.

10.2   Calculate the wavelength of the ultraviolet light used.   (5)

The photocell is now replaced by another photocell with a rubidium cathode. The maximum speed of the ejected photoelectron is 6,10 x 10^5 m·s^{-1} when the same ultraviolet light source is used.

10.3   How does the work function of rubidium compare to that of potassium? Write down only GREATER THAN, SMALLER THAN or EQUAL TO.   (1)

10.4   Explain the answer to QUESTION 10.3.   (3)
                                                                          [11]

                                                         TOTAL: 150

DATA FOR PHYSICAL SCIENCES GRADE 12
PAPER 1 (PHYSICS)

GEGEWENS VIR FISIESE WETENSKAPPE GRAAD 12
VRAESTEL 1 (FISIKA)

TABLE 1: PHYSICAL CONSTANTS/*TABEL 1: FISIESE KONSTANTES*

NAME/*NAAM*	SYMBOL/*SIMBOOL*	VALUE/*WAARDE*
Acceleration due to gravity *Swaartekragversnelling*	g	$9,8 \ m \cdot s^{-2}$
Universal gravitational constant *Universele gravitasiekonstant*	G	$6,67 \times 10^{-11} \ N \cdot m^2 \cdot kg^{-2}$
Speed of light in a vacuum *Spoed van lig in 'n vakuum*	c	$3,0 \times 10^8 \ m \cdot s^{-1}$
Planck's constant *Planck se konstante*	h	$6,63 \times 10^{-34} \ J \cdot s$
Coulomb's constant *Coulomb se konstante*	k	$9,0 \times 10^9 \ N \cdot m^2 \cdot C^{-2}$
Charge on electron *Lading op elektron*	$-e$	$-1,6 \times 10^{-19} \ C$
Electron mass *Elektronmassa*	m_e	$9,11 \times 10^{-31} \ kg$
Mass of Earth *Massa van Aarde*	M	$5,98 \times 10^{24} \ kg$
Radius of Earth *Radius van Aarde*	R_E	$6,38 \times 10^6 \ m$

TABLE 2: FORMULAE/*TABEL 2: FORMULES*

MOTION/*BEWEGING*

$v_f = v_i + a\,\Delta t$	$\Delta x = v_i \Delta t + \frac{1}{2}a\Delta t^2$ or/*of* $\Delta y = v_i \Delta t + \frac{1}{2}a\Delta t^2$
$v_f^{\;2} = v_i^{\;2} + 2a\Delta x$ or/*of* $v_f^{\;2} = v_i^{\;2} + 2a\Delta y$	$\Delta x = \left(\dfrac{v_i + v_f}{2}\right)\Delta t$ or/*of* $\Delta y = \left(\dfrac{v_i + v_f}{2}\right)\Delta t$

FORCE/*KRAG*

$F_{net} = ma$	$p = mv$
$f_s^{\;max} = \mu_s N$	$f_k = \mu_k N$
$F_{net}\Delta t = \Delta p$ $\Delta p = mv_f - mv_i$	$w = mg$
$F = G\dfrac{m_1 m_2}{d^2}$ or/*of* $F = G\dfrac{m_1 m_2}{r^2}$	$g = G\dfrac{M}{d^2}$ or/*of* $g = G\dfrac{M}{r^2}$

WORK, ENERGY AND POWER/*ARBEID, ENERGIE EN DRYWING*

$W = F\Delta x \cos\theta$	$U = mgh$ or/*of* $E_P = mgh$
$K = \dfrac{1}{2}mv^2$ or/*of* $E_k = \dfrac{1}{2}mv^2$	$W_{net} = \Delta K$ or/*of* $W_{net} = \Delta E_k$ $\Delta K = K_f - K_i$ or/*of* $\Delta E_k = E_{kf} - E_{ki}$
$W_{nc} = \Delta K + \Delta U$ or/*of* $W_{nc} = \Delta E_k + \Delta E_p$	$P = \dfrac{W}{\Delta t}$
$P_{av} = Fv_{av}$ / $P_{gemid} = Fv_{gemid}$	

WAVES, SOUND AND LIGHT/*GOLWE, KLANK EN LIG*

$v = f\lambda$	$T = \dfrac{1}{f}$
$f_L = \dfrac{v \pm v_L}{v \pm v_s} f_s$ $f_L = \dfrac{v \pm v_L}{v \pm v_b} f_b$	$E = hf$ or /*of* $E = h\dfrac{c}{\lambda}$
$E = W_o + E_{k(max)}$ or/*of* $E = W_o + K_{max}$ where/*waar* $E = hf$ and/*en* $W_0 = hf_0$ and/*en* $E_{k(max)} = \dfrac{1}{2}mv_{max}^2$ or/*of* $K_{max} = \dfrac{1}{2}mv_{max}^2$	

ELECTROSTATICS/*ELEKTROSTATIKA*

$F = \dfrac{kQ_1Q_2}{r^2}$	$E = \dfrac{kQ}{r^2}$
$V = \dfrac{W}{q}$	$E = \dfrac{F}{q}$
$n = \dfrac{Q}{e}$ or/*of* $n = \dfrac{Q}{q_e}$	

ELECTRIC CIRCUITS/*ELEKTRIESE STROOMBANE*

$R = \dfrac{V}{I}$	emf (ε) = I(R + r) emk (ε) = I(R + r)
$R_s = R_1 + R_2 + ...$ $\dfrac{1}{R_p} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + ...$	$q = I \, \Delta t$
$W = Vq$ $W = VI \, \Delta t$ $W = I^2R \, \Delta t$ $W = \dfrac{V^2\Delta t}{R}$	$P = \dfrac{W}{\Delta t}$ $P = VI$ $P = I^2R$ $P = \dfrac{V^2}{R}$

ALTERNATING CURRENT/*WISSELSTROOM*

$I_{rms} = \dfrac{I_{max}}{\sqrt{2}}$ / $I_{wgk} = \dfrac{I_{maks}}{\sqrt{2}}$ $V_{rms} = \dfrac{V_{max}}{\sqrt{2}}$ / $V_{wgk} = \dfrac{V_{maks}}{\sqrt{2}}$	$P_{ave} = V_{rms}I_{rms}$ / $P_{gemiddeld} = V_{wgk}I_{wgk}$ $P_{ave} = I_{rms}^2R$ / $P_{gemiddeld} = I_{wgk}^2R$ $P_{ave} = \dfrac{V_{rms}^2}{R}$ / $P_{gemiddeld} = \dfrac{V_{wgk}^2}{R}$

CENTRE NUMBER:

EXAMINATION NUMBER:

QUESTION 8.1.2

ATTACH THIS GRAPH SHEET TO YOUR ANSWER BOOK.

Graph of potential difference vs current