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KINGSWOOD COLLEGE

PRELIMINARY EXAMINATION

GRADE 12
TIME: 3 HRS
MARKS: 200

PHYSICAL SCIENCE PAPER 1

SEPTEMBER 2020
EXAMINER: D. PRICE
MODERATOR: G. MAKONI

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:

- A question paper with 18 pages and 12 questions (pages 14 and 16 are blank)
- An answer sheet for Question 1 on page 15.
- A data and formulae sheet on page 17 and 18

2. Use the data and formulae sheet whenever necessary.

3. Where appropriate express answers to TWO decimal places.

4. Show your working in all calculations.

5. Appropriate units should be shown in the answer.

6. Write in black or dark blue pen. (Diagrams and graphs should be drawn in pencil).

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

8. At the end of the exam place the answer sheet and graph paper inside the front cover of the answer book.

DO NOT TURN THIS PAGE OVER UNTIL THE INVIGILATOR TELLS YOU TO

QUESTION 1: Multiple choice questions:

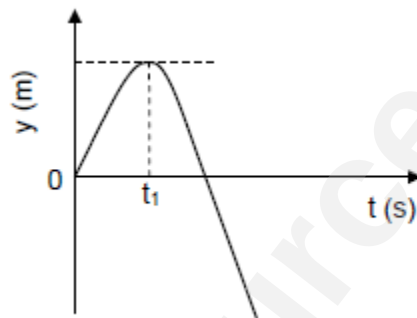
Select the letter that corresponds to the answer which you consider to be the most correct and mark it with an X on the provided answer sheet on page 15

1.1 The force exerted by a surface on an object which is in contact with it and acts perpendicular to the surface is called...

- A. gravitational force
- B. frictional force
- C. normal force
- D. applied force

(2)

1.2 A stone is projected vertically upwards from the top of a building at a speed of $v \text{ m}\cdot\text{s}^{-1}$. The position-time graph below represents the motion of the stone. Ignore the effects of air resistance.

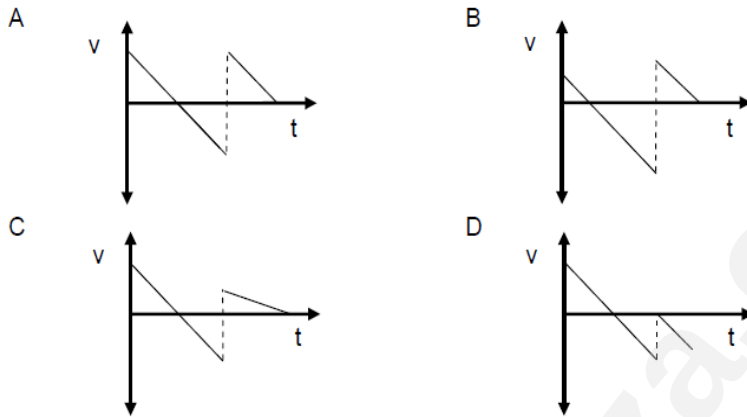


Which ONE of the combinations below regarding the magnitudes of the stone's velocity and acceleration, at time t_1 , is CORRECT?

	MAGNITUDE OF VELOCITY ($\text{m}\cdot\text{s}^{-1}$)	MAGNITUDE OF ACCELERATION ($\text{m}\cdot\text{s}^{-2}$)
A	0	9,8
B	0	0
C	v	0
D	v	9,8

(2)

- 1.3 A ball is projected vertically **upwards** from the ground. It returns to the ground, makes an ELASTIC collision with the ground and then bounces to a maximum height. Ignore air resistance. Which one of the following velocity-time graphs CORRECTLY describes the motion of the ball?



(2)

- 1.4 A ball of mass m travelling due east hits a wall with a speed of $2v$ and bounces BACK with a speed of $3v$. The change in momentum is:

- A. mv due east
- B. mv due west
- C. $5mv$ due east
- D. $5mv$ due west

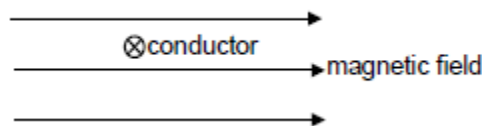
(2)

- 1.5 As a spaceship moves closer to earth, the gravitational force on the spaceship is...

- A. constant
- B. zero
- C. increasing
- D. decreasing

(2)

- 1.6 The diagram below shows a current-carrying conductor lying in a uniform magnetic field directed to the right. The current flows into the page,

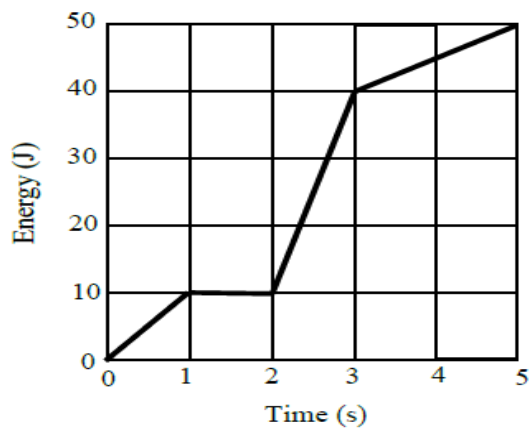


Which ONE of the following arrows shows the direction of the force experienced by the conductors due to the magnetic field?



(2)

- 1.7 An electrical generator is started at time zero. The total electrical energy generated during the first 5 seconds is shown in the graph below.



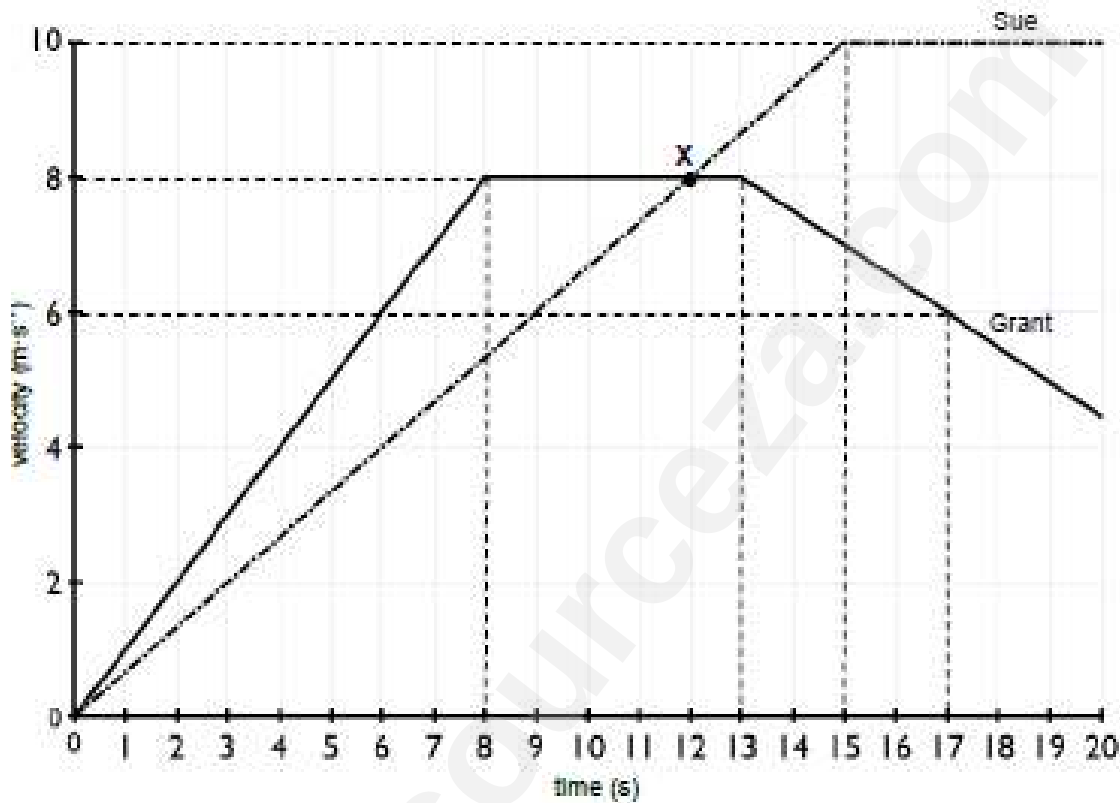
During which time interval in these 5 seconds is the maximum electrical power generated?

- A. 0-1 s
 B. 1-2 s
 C. 2-3 s
 D. 3-5 s (2)
- 1.8 Ohms Law only applies when the...
 A. temperature of the conductor is constant
 B. potential difference across the conductor is constant
 C. current through the conductor is constant
 D. conductor is connected in a series circuit (2)
- 1.9 The cost of using a 500 W appliance for 20 minutes is X. What is the cost of electricity per kWh?
 A. 6X
 B. $3X/2$
 C. $2X/3$
 D. X (2)
- 1.10 The work function of a metal is the _____ needed to emit an electron from the surface of a metal.
 A. maximum frequency
 B. minimum frequency
 C. maximum energy
 D. minimum energy (2)

TOTAL FOR QUESTION 1: [20]

QUESTION 2:

Two athletes, Grant and Sue, challenge each other to a race over 100 meters. The velocity-time graphs for both Sue and Grant running the race are shown below:

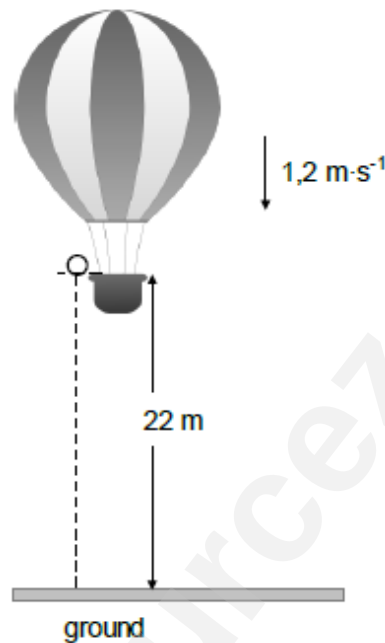


- 2.1 Define *acceleration*. (2)
- 2.2 Determine the magnitude of Grant's acceleration during the first 8 seconds of the race. (2)
- 2.3 Describe Grant's motion between 8 and 13 seconds (2)
- 2.4 Determine how far Grant ran in 17 seconds. (4)
- 2.5 The two graphs intersect at point X. What can you conclude about the athletes at that point? (2)
- 2.6 Determine how long Sue takes to complete the 100 m race. (4)

TOTAL FOR QUESTION 2: [16]

QUESTION 3:

A hot-air balloon moves vertically **downwards** at a **constant velocity** of $1,2 \text{ m}\cdot\text{s}^{-1}$. When it reaches a height of 22 m from the ground, a ball is dropped from the balloon. Refer to the diagram below.



Assume that the dropping of the ball has **no effect** on the movement of the hot air balloon. Ignore any air friction for the motion of the ball while it is falling.

- 3.1 Define *velocity*. (2)
- 3.2 Is the hot-air balloon in free fall? Give a reason for your answer. (2)
- 3.3 Calculate the time it takes for the ball to hit the ground after it is released (4)

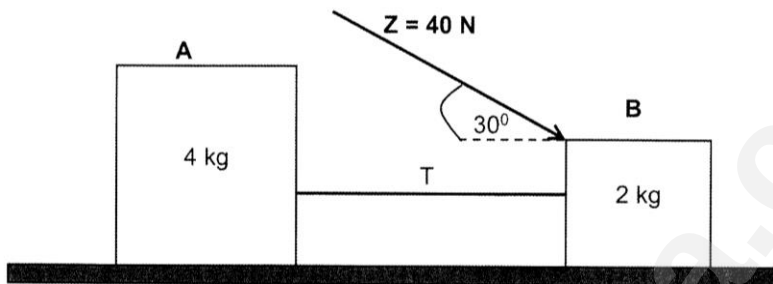
When the ball lands on the ground it is in contact with the ground for 0.3 seconds and then it bounces vertically upwards with a speed of $15 \text{ m}\cdot\text{s}^{-1}$.

- 3.4 Calculate how high the BALLOON is from the ground when the BALL reaches its maximum height after its first bounce. (5)
- 3.5 Draw a displacement-time sketch graph of the motion of the BALL from when it leaves the hot-air balloon to where it reaches its maximum height after its first bounce. Use the height at which it left the balloon as the reference point. (4)

TOTAL FOR QUESTION 3: [17]

QUESTION 4:

Two blocks A and B are connected by a string of negligible mass. The mass of A is 4 kg and the mass of B is 2 kg. Block B is pushed by a force Z of magnitude 40 N acting at an angle of 30° to the horizontal. The coefficient of kinetic friction between block B and the horizontal surface is 0.25. Block A experiences a frictional force of 9.8 N during its motion. The system accelerates to the right.

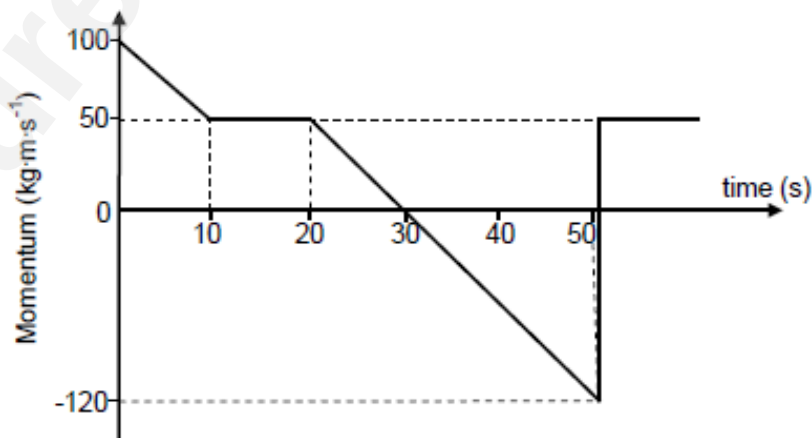


- 4.1 Draw a labelled free body diagram to show all the forces acting on the 2 kg block. (5)
- 4.2 The magnitude of the vertical component of force Z is 20 N. Calculate the magnitude of the kinetic frictional force experienced by block B. (4)
- 4.3 State *Newton's Second Law of motion*. (2)
- 4.4 Calculate the magnitude of the tension T in the string by applying Newton's Second Law of motion SEPARATELY on each of the blocks. (5)

TOTAL FOR QUESTION 4: [16]

QUESTION 5:

The momentum versus time graph of object A, originally moving horizontally **EAST**, is shown below:



- 5.1 Momentum is a vector physical quantity. Define a *vector*. (2)
- 5.2 Define a *resultant vector*. (2)

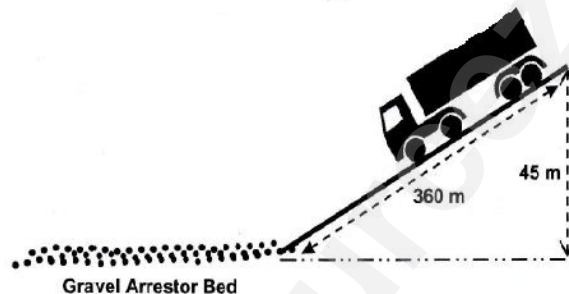
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- 5.3 The net force on object A is zero between $t = 10 \text{ s}$ and $t = 20 \text{ s}$.
Use the graph and a relevant equation to explain why this statement is TRUE. (2)
- 5.4 Calculate the magnitude of the impulse that object A experiences between $t = 20 \text{ s}$ and $t = 50 \text{ s}$. (2)
- 5.5 At $t = 50 \text{ s}$, object A collides with another object B, which has a momentum of $70 \text{ kg}\cdot\text{m}\cdot\text{s}^{-1}$ EAST. Use the information from the graph and the relevant principle to calculate the momentum of object B after the collision. (4)

TOTAL FOR QUESTION 5: [12]

QUESTION 6:

A truck of mass 5900 kg accelerates from $0 \text{ km}\cdot\text{h}^{-1}$ at the top of a slope to $32.4 \text{ km}\cdot\text{h}^{-1}$ at the bottom. The slope is 360 m long and the truck starts 45 m above level ground. The average frictional force on the truck during the journey down the slope is $2.87 \times 10^4 \text{ N}$.

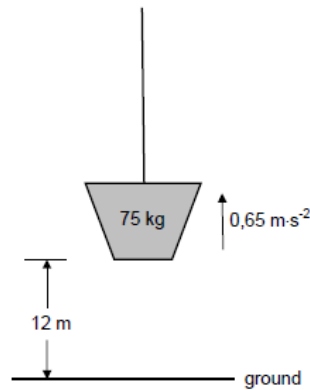


- 6.1 Convert $32.4 \text{ km}\cdot\text{h}^{-1}$ to $\text{m}\cdot\text{s}^{-1}$. (2)
- 6.2 Calculate how much potential energy the truck has at the top of the slope. (2)
- 6.3 Define *kinetic energy*, (2)
- 6.4 Calculate the increase in kinetic energy of the truck. (3)
- 6.5 Calculate the work done by the friction force? (3)
- 6.6 Calculate the work the engine does while the truck is accelerating. (4)
- 6.7 Calculate the power produced by the engine if the truck takes 80 seconds to reach the bottom of the slope. (2)
- 6.8 Define *work done* (2)
- 6.9 At the bottom of the slope the brakes of the truck fail and it cannot stop as it enters a gravel arrestor bed. The bed is 25 m long and provides a resistive force of 0.25 times the weight of the truck. Will the bed be long enough to stop the truck? Show your justification using relevant calculations (5)

TOTAL FOR QUESTION 6: [25]

QUESTION 7:

A load of mass 75 kg is initially at rest on the ground. It is then pulled vertically upwards at a constant acceleration of 0.65 m.s^{-2} by means of a light inextensible rope. Refer to the diagram below. Ignore air resistance, rotational effects and the mass of the rope.



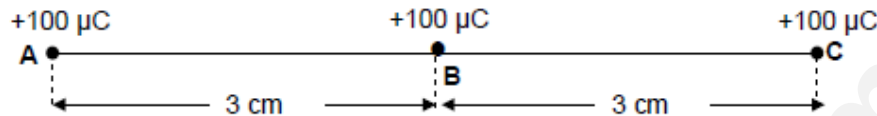
- 7.1 Draw a labelled free body diagram of the forces acting on the load when it is being pulled up. The length of the vectors do not have to be accurate but MUST indicate the magnitude of the forces relative to each other. (3)
- 7.2 Calculate the work done on the load by the gravitational force when the load has reached a height of 12 m (3)
- 7.3 Determine the net force acting on the load as it accelerates at 0.65 m.s^{-2} (2)
- 7.4 State the *work-energy theorem* (2)
- 7.5 Use the work-energy theorem to calculate the speed of the load when it is at a height of 12 m above the ground. (4)

TOTAL FOR QUESTION 7: [14]

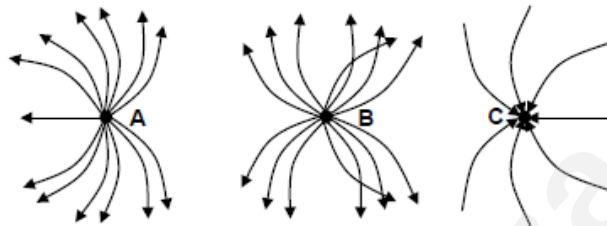
QUESTION 8:

- 8.1 A satellite of mass 200 kg is orbiting the earth at a distance of **d** from the earth's surface. The weight of the satellite at that position is 10% less than its weight on the earth's surface. The mass of earth is $5.98 \times 10^{24} \text{ kg}$ and the radius of the earth is 6380 km.
 - 8.1.1 State *Newton's Law of Universal Gravitation*. (2)
 - 8.1.2 Calculate the distance **d** from the earth's surface at which the satellite is orbiting (7)
 - 8.1.3 The satellite is moved to a new position where the distance from the centre of the earth is twice the radius of the earth. Determine the weight of the satellite at the new position. (3)

- 8.2 Three $+100\ \mu\text{C}$ point charges A, B and C are equally spaced on a straight line in a vacuum. The charges are a distance of 3 cm from each other as shown in the sketch below.



A learner sketches the electric field pattern produced by the three charges as shown below.

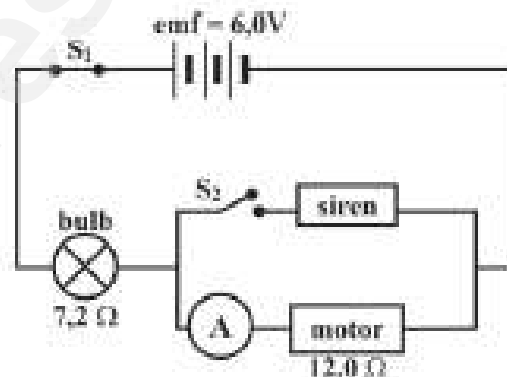


- 8.2.1 Write down TWO mistakes that the learner made. (2)
 8.2.2 Calculate the net electrostatic force experienced by point charge C. (5)
 8.2.3 Write down the net electrostatic force experienced by point charge B. (1)

TOTAL FOR QUESTION 8: [20]

QUESTION 9:

Tsepo has a toy ambulance which has a siren and an electric motor. The circuit diagram for the electric circuit of the ambulance is given below. The resistance of the battery, ammeter, switches and connecting wires can be ignored,



When Tsepo closes ONLY switch 1 (S_1), with switch 2 (S_2) open, the light comes on while the ambulance moves at a constant speed.

- 9.1 Calculate the reading on the ammeter when switch 1 (S_1) is closed and switch 2 (S_2) is open. (3)
 9.2 Calculate the rate of energy transfer in the bulb when only switch 1 (S_1) is closed. (3)

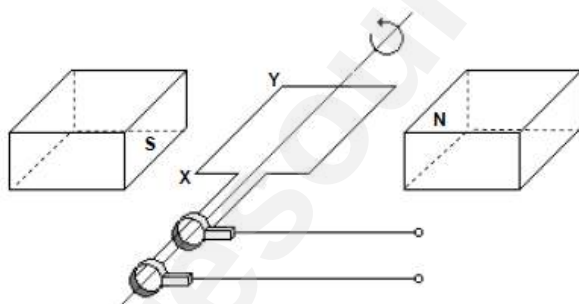
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- 9.3 Define *potential difference*. (2)
- 9.4 When Tsepo closes both switches (S_1 and S_2), the siren sounds and the reading on the ammeter is 200 mA.
- 9.4.1 Calculate the potential difference across the motor. (3)
- 9.4.2 Calculate the new current through the bulb (3)
- 9.4.3 Calculate the total resistance of the circuit (3)
- 9.4.4 Calculate the resistance of the siren. (4)
- 9.5 How will the brightness of the bulb change when the siren sounds?. (Write only **increase, decrease** or **no change**). (1)
- 9.6 Explain your answer to Question 9.4 by referring to one or more suitable equation. (2)
- 9.7 How will the speed of the ambulance change when the siren sounds?. (Write only **increase, decrease** or **no change**). (1)
- 9.8 Explain your answer to Question 9.6 by referring to one or more suitable equations. (2)

TOTAL FOR QUESTION 9: [27]

QUESTION 10:

A coil is rotated **anti-clockwise** in a uniform magnetic field. The diagram below shows the position at the instant the coil lies parallel to the magnetic field and the normal to the plane of the coil lies perpendicular to the magnetic field.



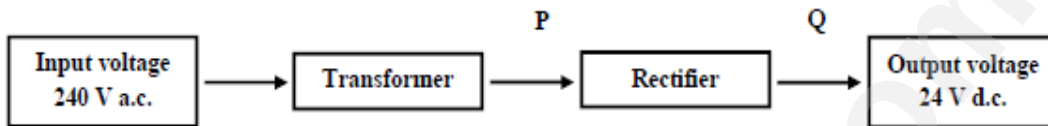
- 10.1 Determine the direction of the current in segment XY when the coil is in the position shown above. Write only **X to Y** or **Y to X**. (2)
- 10.2 Assume that the speed and direction of rotation are constant. Starting at the position shown in the diagram, draw a sketch graph of induced emf against time for one full rotation that represents that output of this device. (2)
- 10.3 State *Faraday's Law of Electromagnetic Induction*. (2)
- 10.4 The speed at which the coil turns is now doubled. On the same set of axes drawn in Question 10.2 draw a sketch graph of potential difference against time for one full rotation. Label this graph 10.4. (2)

TOTAL FOR QUESTION 10: [8]

QUESTION 11:

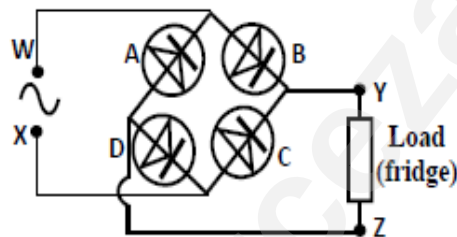
A fridge is connected via a transformer and a rectifier to a 240 V alternating current (AC) source as shown in the simplified flow chart in Diagram 1 below.

Diagram 1: Flow chart to show how voltage is changed from 240 V a.c. to 24 V d.c.



The rectifier consists of a number of diodes connected as shown in Diagram 2

Diagram 2: Arrangement of diodes in rectifier

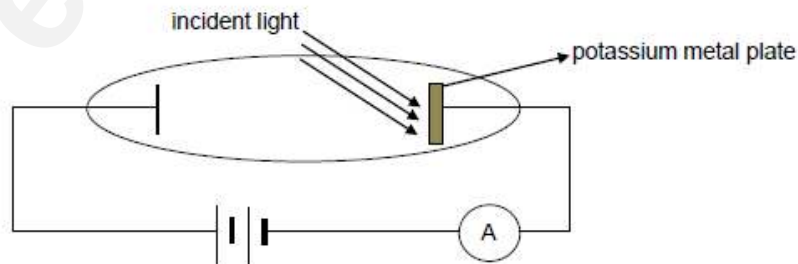


- 11.1 What type of transformer is required in diagram 1? Write only **step up** or **step down** Give a reason for your answer. (2)
- 11.2 Define a *diode*. (2)
- 11.3 What is the function of the rectifier? (2)
- 11.4 Describe the path taken by conventional current in the circuit shown in diagram 2 when W is positive. Indicate which diodes (A, B, C, D) the current passes through and the direction of the current through the load (**Y to Z** or **Z to Y**) (3)

TOTAL FOR QUESTION 11: [9]

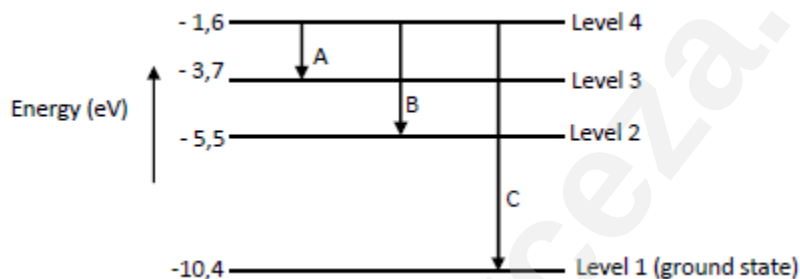
QUESTION 12:

- 12.1 A potassium metal plate is irradiated with light of wavelength $5 \times 10^{-7} \text{ m}$ in an arrangement as shown below. The threshold frequency of potassium is $5,55 \times 10^{14} \text{ Hz}$.



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- 12.1.1 Define *threshold frequency*. (2)
- 12.1.2 Calculate the energy of a photon of the light of wavelength 5×10^{-7} m incident on the metal plate. (3)
- 12.1.3 Using a suitable calculation, prove that the ammeter will show a reading. (4)
- 12.1.4 The intensity of the light is now increased. Explain why this change causes an increase in the ammeter reading. (3)
- 12.2 Line emission spectra are produced as a result of electron transitions between energy level of the atom. The diagram below shows some of the outer energy levels of the mercury atom. An electron is excited to the -1.6 eV energy level (Level 4). The diagram shows three possible ways that it can return to the -10.4 eV energy level (Level 1, ground state)



The three energy transitions produce three different spectral lines. Which transition (A, B or C) will produce the spectral line with:

- 12.2.1 The longest wavelength, (2)
- 12.2.2 The highest frequency (2)

TOTAL FOR QUESTION 12: [16]

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Name: _____

Answer sheet for question 1

- Put an X over the box which contains the letter which corresponds to the correct answer as shown below.

A	~~B~~	C	D
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- There is only one correct answer for each question.
- Remember to detach this answer sheet and put it in your answer booklet.

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

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**EXAMINATION DATA SHEET FOR THE PHYSICAL SCIENCES
(PHYSICS)**

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Acceleration due to gravity	g	9,8 m·s ⁻²
Speed of light in a vacuum	c	3,0 × 10 ⁸ m·s ⁻¹
Universal gravitational constant	G	6,7 × 10 ⁻¹¹ N·m ² ·kg ⁻²
Coulomb's constant	k	9,0 × 10 ⁹ N·m ² ·C ⁻²
Magnitude of charge on electron	e	1,6 × 10 ⁻¹⁹ C
Mass of an electron	m _e	9,1 × 10 ⁻³¹ kg
Planck's constant	h	6,6 × 10 ⁻³⁴ J·s
1 electron volt	eV	1,6 × 10 ⁻¹⁹ J

TABLE 2 PHYSICS FORMULAE**MOTION**

$v = u + at$ or $v_f = v_i + a\Delta t$	$s = \left(\frac{v+u}{2}\right)t$ or $\Delta x = \left(\frac{v_f+v_i}{2}\right)\Delta t$
$v^2 = u^2 + 2as$ or $v_f^2 = v_i^2 + 2a\Delta x$	$s = ut + \frac{1}{2}at^2$ or $\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$

FORCE AND MOMENTUM

$F_{net} = ma$	$F_{net} = \frac{\Delta p}{\Delta t}$ or $F_{net}\Delta t = m\Delta v$	$J = \Delta p = mv - mu$ or $J = \Delta p = mv_f - mv_i$
$p = mv$	$F_g = mg$	$F_{fs}^{max} = \mu_s F_N$ $F_{fk} = \mu_k F_N$

WORK, ENERGY AND POWER

$W = Fs$ or $W = F\Delta x$ or $W = F\Delta x \cos \theta$	$P = \frac{W}{t}$	$P = Fv$
$E_p = mgh$	$E_k = \frac{1}{2}mv^2$	$W_{net} = \Delta E_K$
efficiency = $\frac{\text{power}_{out}}{\text{power}_{in}} \times 100$		

GRAVITATIONAL AND ELECTRIC FIELDS

$F = G \frac{m_1 m_2}{r^2}$	$g = \frac{F}{m}$	$g = G \frac{M}{r^2}$
$F = k \frac{q_1 q_2}{r^2}$	$E = \frac{F}{q}$	$E = \frac{kQ}{r^2}$

ELECTRIC CIRCUITS

$I = \frac{q}{t}$	$V = \frac{W}{q}$
$R = \frac{V}{I}$	$emf = I(R_{ext} + r)$ or $emf = V_{load} + V_{internal\ resistance}$
$R_s = R_1 + R_2 + \dots$	$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$P = \frac{W}{t}$ or $W = Pt$	
$W = VIt$ or $W = I^2 R t$ or $W = \frac{V^2}{R} t$	
$P = VI$ or $P = I^2 R$ or $P = \frac{V^2}{R}$	

ELECTRODYNAMICS

$\Phi = BA \cos \theta$	$emf = -\frac{N \Delta \Phi}{\Delta t}$	$F = IB \ell \sin \theta$
$V_p I_p = V_s I_s$	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$	

PHOTONS AND ELECTRONS

$c = f \lambda$	$E = hf$ or $E = \frac{hc}{\lambda}$	
$E = W_0 + E_{K(max)}$	$W_0 = hf_0$	$E_{K(max)} = \frac{1}{2}mv_{max}^2$