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**ST. MARY'S DSG, KLOOF
PHYSICAL SCIENCES
TRIALS PAPER 1: PHYSICS**

GRADE 12

August 2021

TIME: 3 hours + 10 mins reading

MARKS: 200

Examiners and Moderators: Mrs K. Bolton, Mrs G. Main and Mrs T. Kirsten

Read the Following Instructions Carefully:

1. This paper consists of:
 - A question paper of 20 pages
 - A separate yellow answer sheet
 - A green data sheet
 - An answer booklet
2. Read the questions carefully. Answer **ALL** questions.
3. Write your NAME (not your examination number) on your question paper, so you can get your own paper back after Trials.
4. Number your answers exactly as the questions are numbered. **Answer each new question on a new page in your answer booklet.**
5. Please hand in the yellow answer sheet inside your answer booklet.
6. Write legibly and present your work neatly.
7. All working should be shown and units **MUST** be given with answers. Work to two significant figures. **Make sure your calculator is in the correct mode.**
8. Consult the data sheet where necessary.

Acknowledgements:

FS 2021 April Control Test;
BC 2020; HBC 2020 prelim;
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Victorian Certificate of Education 2020
GWH prelim 2020
FC Prelim 2020;
St Benedict's Prelim 2020
Woodridge College Sept 2020
St Alban's PHSC Prelim 2020
St. Andrew's CDSG Trials 2020

<https://www.chegg.com/homework-help/questions-and-answers/>

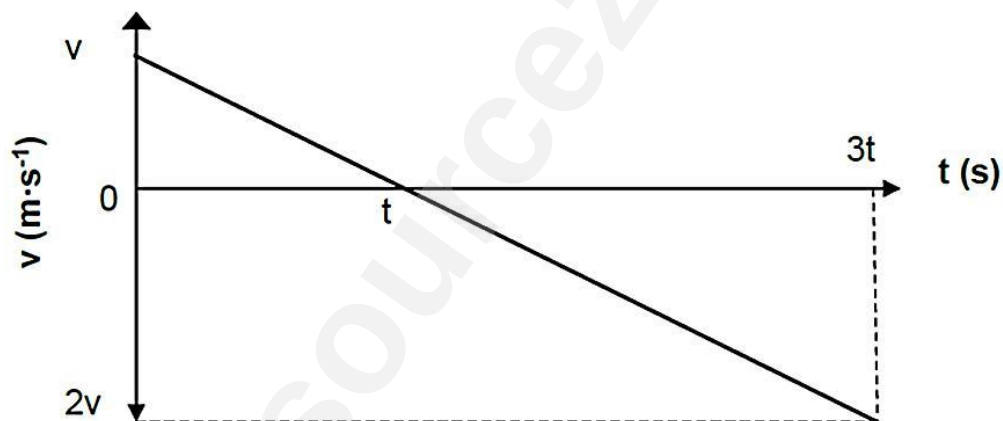
QUESTION 1 MULTIPLE CHOICE

Answer these questions on the multiple-choice **ANSWER SHEET** provided. Make a cross (X) in the box corresponding to the letter which you consider to be the most correct.

- 1.1 Two forces, X and Y, have a resultant of 5 N. If the magnitude of X is 14 N then the magnitude of Y could be:

A 6 N
B 8 N
C 10 N
D 20 N

- 1.2 The velocity versus time graph below represents the movement of an object under the influence of gravitational force ONLY.



The displacement of the object at time $3t$ is ...

A $- \frac{5}{2} vt$
B $7 vt$
C $\frac{7}{2} vt$
D $- \frac{3}{2} vt$

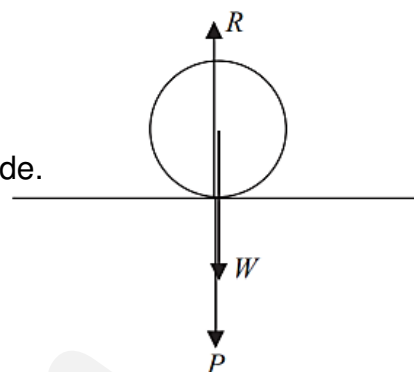
1.3 An apple is at rest on the ground.

The diagram below shows three forces of equal magnitude.

W = weight of apple

P = force of apple on ground

R = normal contact force of ground on apple



Which row in the table shows Newton's first and third laws being applied correctly?

	Newton's first law	Newton's third law
A	$P = W$	$R = P$
B	$R = P$	$P = W$
C	$W = R$	$P = W$
D	$W = R$	$R = P$

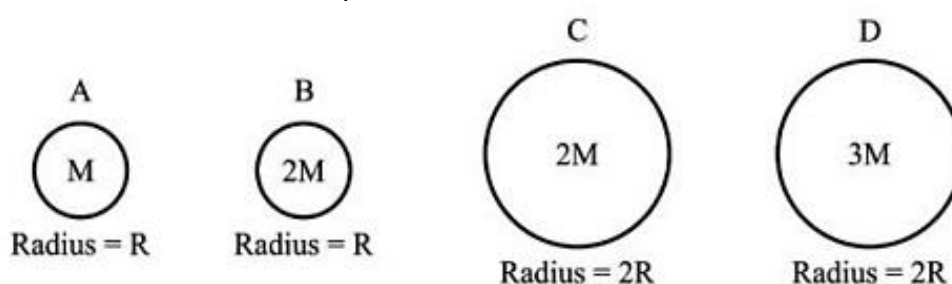
1.4 A body moving at a constant velocity has kinetic energy E , as well as momentum p . If the velocity of the body is doubled, which one of the following correctly gives the magnitudes of both kinetic energy and momentum?

	Kinetic energy	Momentum
A	$2E$	$2p$
B	$4E$	$4p$
C	$4E$	$2p$
D	$2E$	$4p$

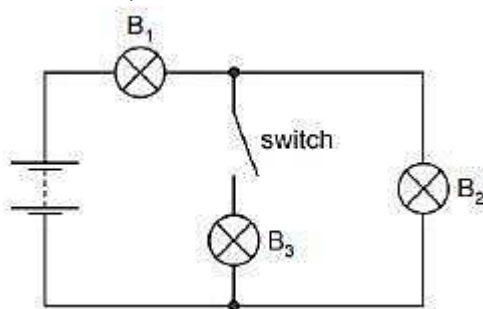
1.5 A motor of input power 160 W raises a mass of 8 kg vertically at a constant speed of $0,5 \text{ m.s}^{-1}$. What is the efficiency of the system?

- A 0,63%
- B 25%
- C 50%
- D 100%

1.6 Which one of the planets depicted will have the greatest free-fall acceleration on the surface of the planet?



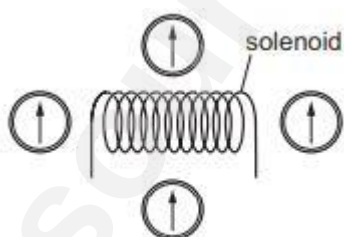
- 1.7 B₁, B₂ and B₃ are three identical lamps. They are connected to a battery with zero internal resistance, as shown.



Initially the switch is closed. The switch is then opened and lamp B₃ goes out. What happens to the brightness of lamps B₁ and B₂ when the switch is opened?

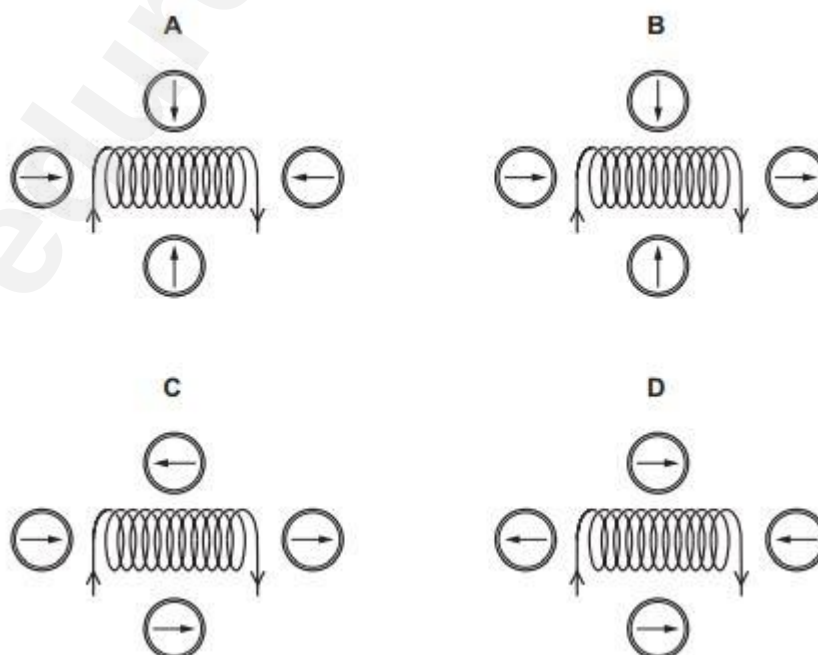
	Brightness of lamp B ₁	Brightness of lamp B ₂
A	decreases	decreases
B	increases	decreases
C	decreases	increases
D	increases	increases

- 1.8 Four small compasses are placed around a solenoid.

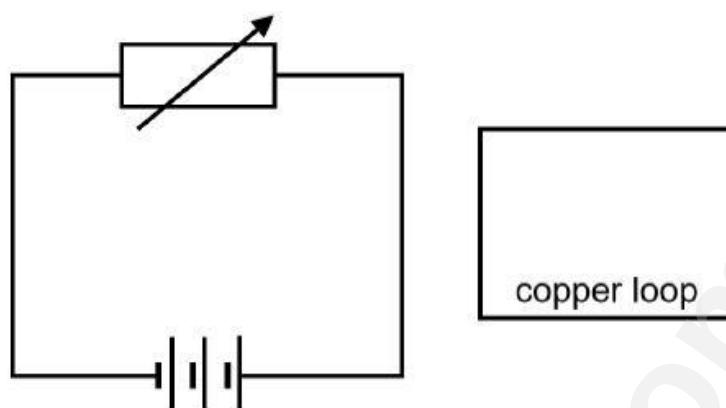


A current is now switched on in the solenoid.

Which diagram shows possible new directions of the compass needles?



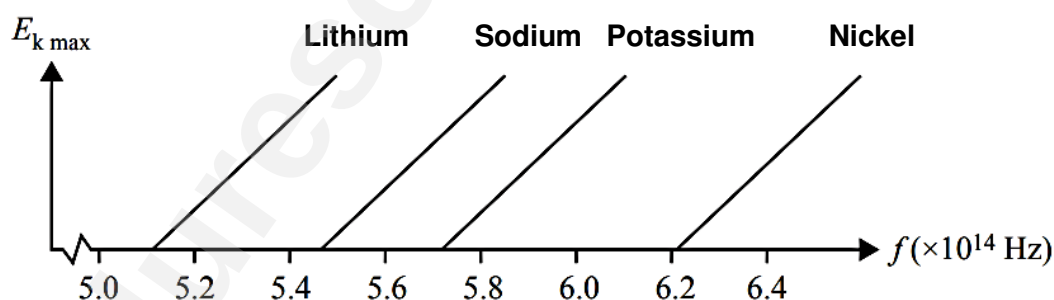
1.9 A circuit shown below is positioned next to a copper loop.



Which of the following correctly describes the flux and the direction of the induced current in the copper loop when the resistance of the variable resistor decreases?

	Flux in copper loop	Direction of induced current in copper loop
A	Into the page	Clockwise
B	Into the page	Anticlockwise
C	Out of the page	Clockwise
D	Out of the page	Anticlockwise

1.10 The diagram below shows a plot of maximum kinetic energy, $E_{k \max}$, versus frequency, f , for various metals capable of emitting photoelectrons.



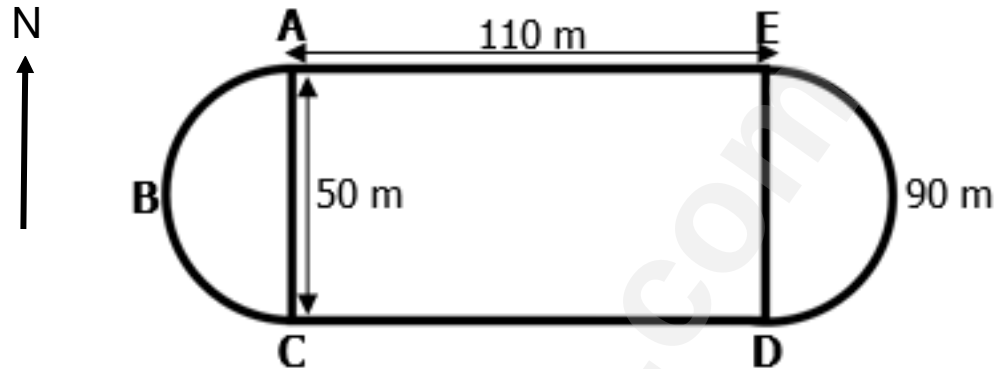
Which one of the following correctly ranks these metals in terms of their work function, from HIGHEST to LOWEST in numerical value?

- A sodium, potassium, lithium, nickel
- B nickel, potassium, sodium, lithium
- C potassium, nickel, lithium, sodium
- D lithium, sodium, potassium, nickel

[20]

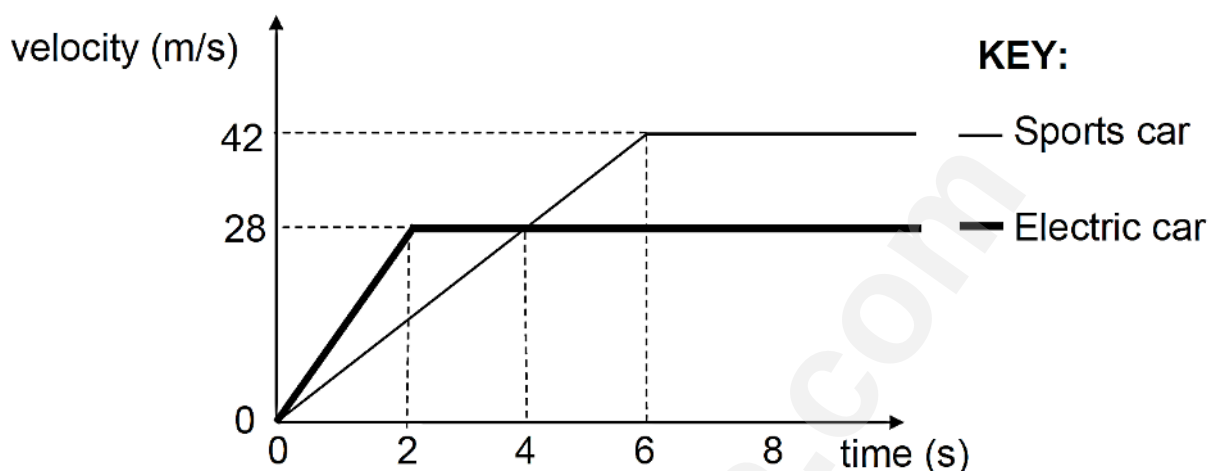
QUESTION 2 KINEMATICS

- 2.1 An athlete runs around the track shown below at a **constant speed** in an **anticlockwise** direction.



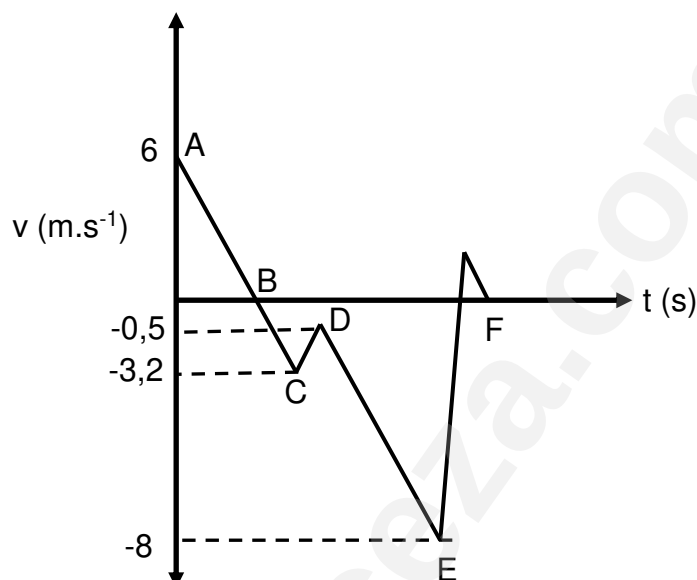
- 2.1.1 Define *speed* and state whether it is a vector or a scalar quantity. (3)
- 2.1.2 Define *velocity* and state whether it is a vector or a scalar quantity. (3)
- 2.1.3 Use the diagram of the track to explain how the magnitude of the **average velocity** of the athlete from A to C (via B) would differ from the **average speed** of the athlete from A to C (via B). (2)
- 2.1.4 Use the diagram of the track to explain why the **instantaneous** velocity of the athlete changes when she runs at a constant speed between A and C (via B). (2)
- 2.1.5 If the athlete were to then run directly from C to D, determine her resultant displacement from point A. (4)

- 2.2 An electric car and a sports car travel **due South** on a straight road. The velocity of each car is shown against time in the graph below.



- 2.2.1 Define *acceleration*. (2)
- 2.2.2 Calculate the acceleration of the sports car from 0 - 6 s. (4)
- 2.2.3 Describe the relationship between the velocities of the sports car and the electric car at 4 seconds. (1)
- 2.2.4 How far has the electric car travelled after 6 seconds? (3)
- 2.2.5 At what time (after the start) will the sports car be next to the electric car? (4)

- 2.3 A ball is thrown vertically upwards from a **position above the ground (A)** with a velocity of 6 m.s^{-1} . On the way down the ball crashes through a thin horizontal glass pane (**C**) and then continues downward, eventually bouncing on the ground before coming to rest (**F**). The velocity-time sketch graph for the motion of the ball is shown below. Ignore air resistance.



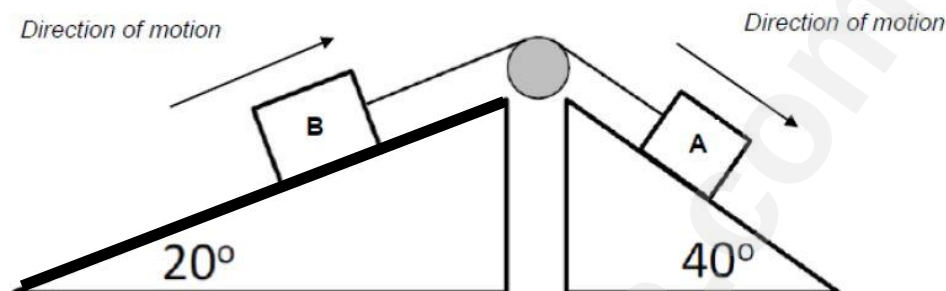
- 2.3.1 Write down the magnitude and direction of the acceleration of the ball when it reaches position **B** as indicated on the graph. (2)
- 2.3.2 Using EQUATIONS OF MOTION and the supplied information on the graph, calculate:
- 2.3.2.1 the distance between the pane of glass (**C**) and the initial position (**A**) from which the ball was thrown. (4)
- 2.3.2.2 the time taken for the ball to travel from position **D** to position **E**. (4)
- 2.3.3 Using the axes on the ANSWER SHEET, draw a rough position-time graph for the motion of the ball. Indicate the points **A** to **F** on your graph. No values are required. **TAKE THE GROUND AS ZERO.** (5)

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QUESTION 3 NEWTON'S LAWS

Two blocks, **A** and **B**, are arranged as indicated in the sketch.

- Each have a mass of 3 kg.
- The 40° incline is frictionless.
- The 20° incline has a coefficient of kinetic friction of 0,1.



The objects accelerate in the direction indicated on the sketch.

- 3.1 State *Newton's Second Law of Motion* in words. (2)
- 3.2 Draw a free body diagram for the block labelled **B**. (5)
- 3.3 Define *normal force*. (2)
- 3.4 Calculate the magnitude of the frictional force acting on block **B**. (4)
- 3.5.1 Use Newton's second law to write the equation $F_{net} = ma$ in terms of all the forces parallel to the slope acting on **block A**. Simplify fully. (2)
- 3.5.2 Use Newton's second law to write the equation $F_{net} = ma$ in terms of all the forces parallel to the slope acting on **block B**. Simplify fully. (3)
- 3.5.3 Calculate the magnitude of the tension in the cable. (2)
- 3.6 Calculate the magnitude of the acceleration of block **A**. (2)
- 3.7 The angle of the incline of **block A** is decreased. What effect would this have on the magnitude of the acceleration of the system? Explain using relevant formulae. No calculations needed. (4)

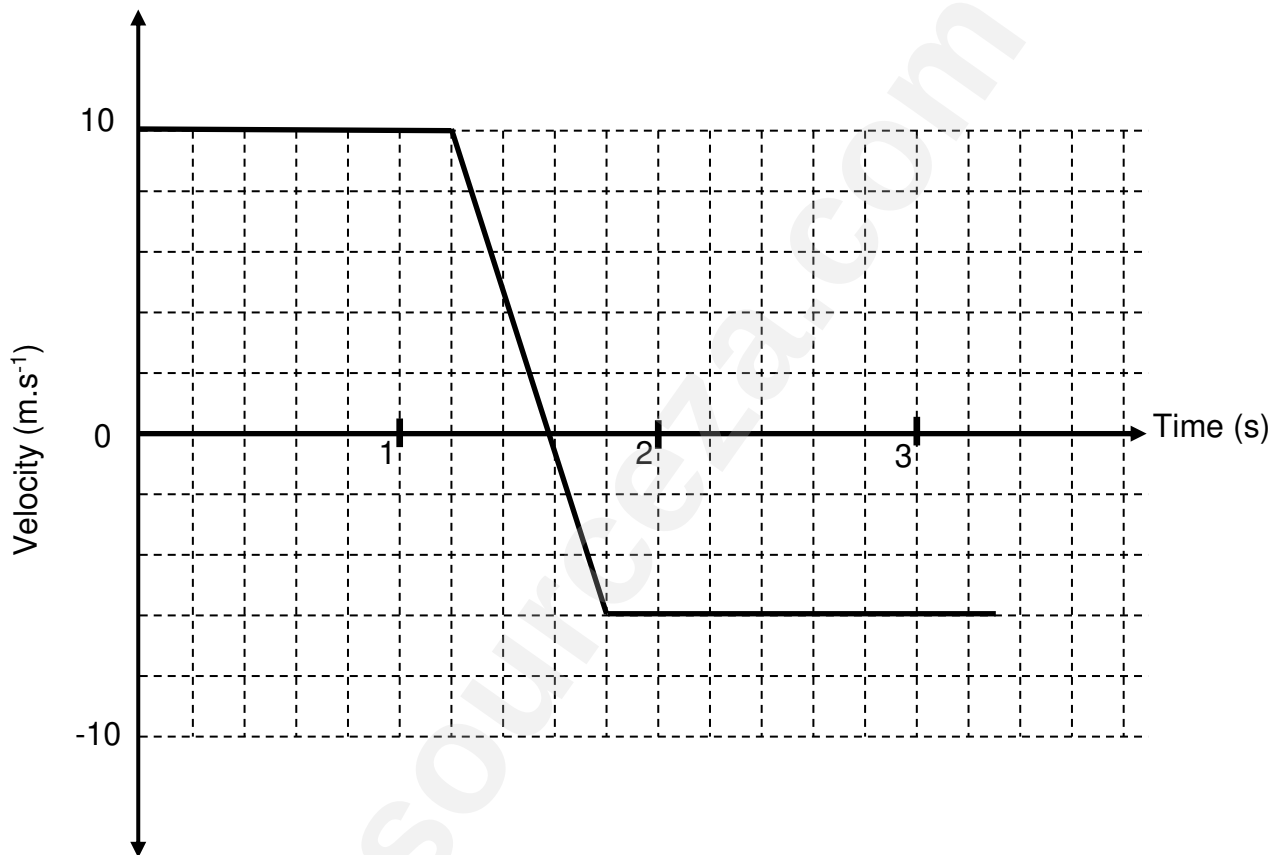
[26]

QUESTION 4 MOMENTUM

Ball **P**, with a mass m , is initially rolling EASTWARDS when it collides with an identical ball **Q**, which is rolling WESTWARDS at 15 m.s^{-1} .

Ignore the rotation effects of the balls and friction.

The graph below shows how the velocity of ball **P** changes with time.

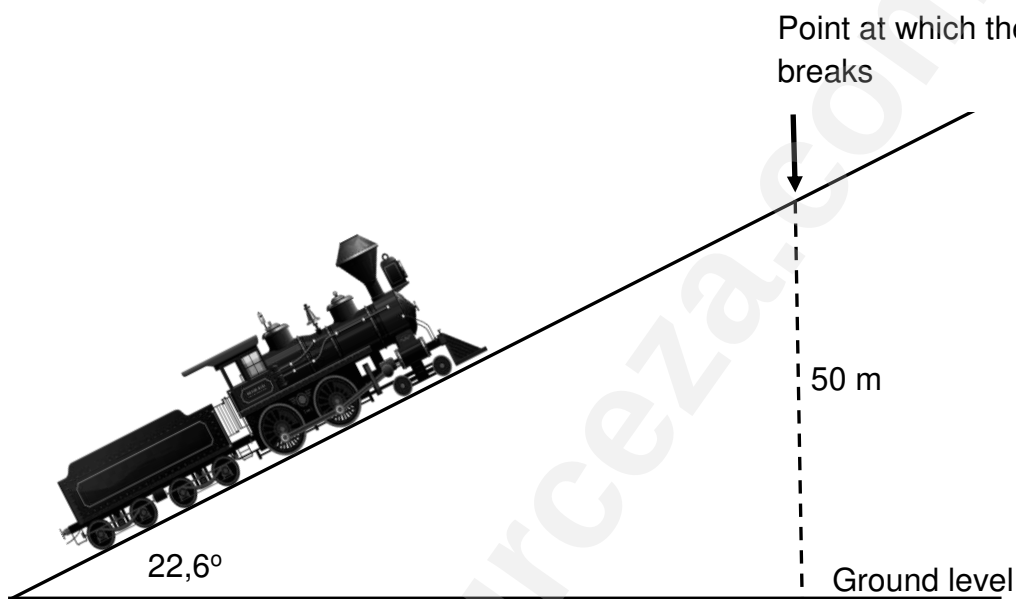


- 4.1 Define the term *impulse*. (2)
- 4.2 Calculate the velocity of ball **Q** after the collision. (5)
- 4.3 It is observed that the kinetic energy of the system DECREASES by $28,8 \text{ J}$. Calculate:
 - 4.3.1 Mass m . (5)
 - 4.3.2 The magnitude of the net force acting on ball **P** during the collision. (4)

[16]

QUESTION 5 ENERGY AND POWER

A train engine (5000 kg) and a carriage (2000 kg) are travelling up a slope inclined at $22,6^\circ$ at a speed of 10 m.s^{-1} . As the train engine and carriage reach a vertical height of 50 m from the bottom of the slope the linkage between the train engine and carriage breaks. The train engine continues to move up the hill and the carriage moves freely.



- 5.1 State the *principle of conservation of mechanical energy*. (2)
- 5.2 Using energy principles, calculate the maximum possible height above ground level that the CARRIAGE could reach after the linkage breaks. (Assume NO FRICTION.) (4)

In reality, the carriage reaches a vertical height of 54 m above the ground level before it stops due to friction.

- 5.3 Calculate the amount of work done by friction to stop the carriage. (4)
- 5.4 Calculate the distance (parallel to the slope) that the carriage travels to reach a vertical height of 54 m after the linkage breaks. (2)
- 5.5 Calculate the magnitude of the frictional force acting on the carriage. (3)

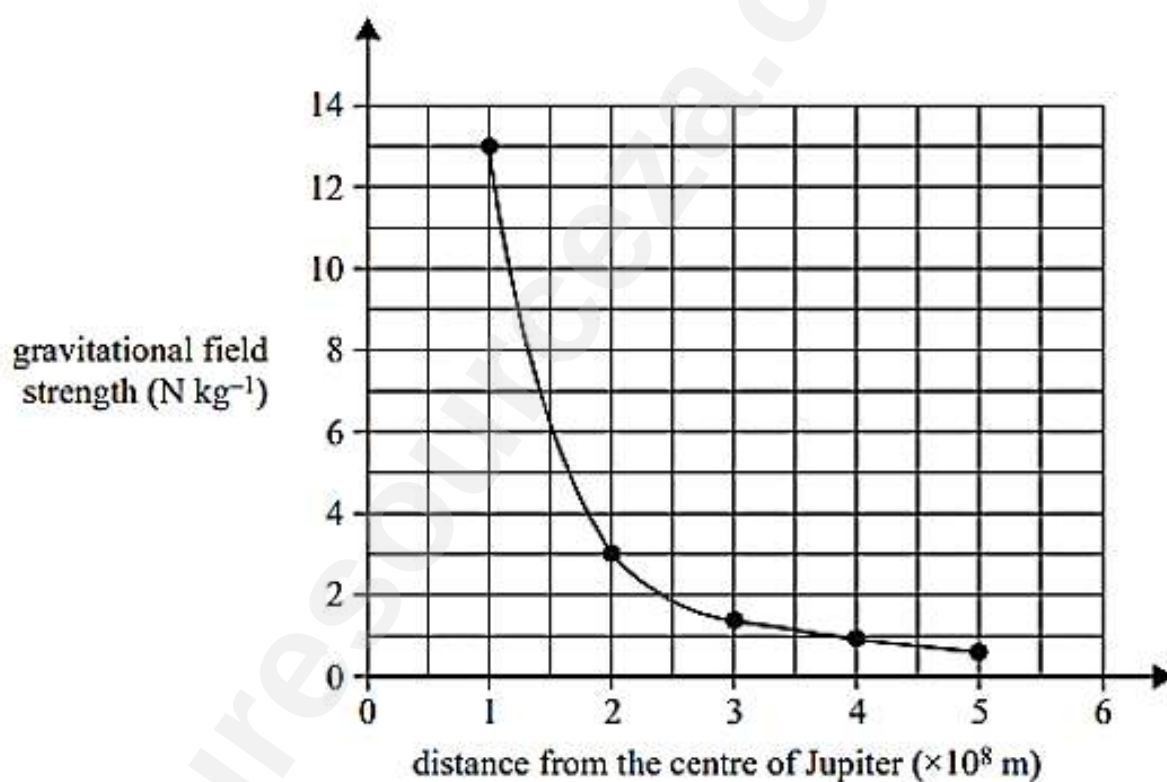
[15]

QUESTION 6 FIELDS

6.1 The spacecraft *Juno* has been put into orbit around Jupiter. The table below contains information about the planet Jupiter and the spacecraft *Juno*.

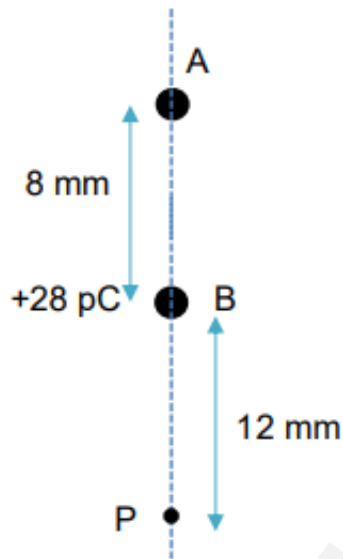
Mass of Jupiter	$1,9 \times 10^{27} \text{ kg}$
Radius of Jupiter	$7 \times 10^7 \text{ m}$
Mass of spacecraft <i>Juno</i>	1500 kg

The graph shows gravitational field strength (N.kg^{-1}) as a function of distance from the centre of Jupiter.



- 6.1.1 Define *gravitational field*. (2)
- 6.1.2 Calculate the gravitational force acting on *Juno* by Jupiter when *Juno* is at a distance of $2 \times 10^8 \text{ m}$ from the centre of Jupiter. (3)
- 6.1.3 Use the ratio method to determine by what factor the gravitational force acting on the spacecraft *Juno* changes as it moves from a distance of $2 \times 10^8 \text{ m}$ to a distance of $1 \times 10^8 \text{ m}$ from the centre of Jupiter. (2)

- 6.2 Two identical isolated charged metal spheres, **A** and **B** are arranged as shown in the diagram below.



- Sphere **B** has a charge of $+28 \text{ pC}$.
- A point **P** is located 12 mm below the charged sphere **B**.
- The net electric field at point **P** is 805 N.C^{-1} downwards.

Calculate the charge on sphere **A**.

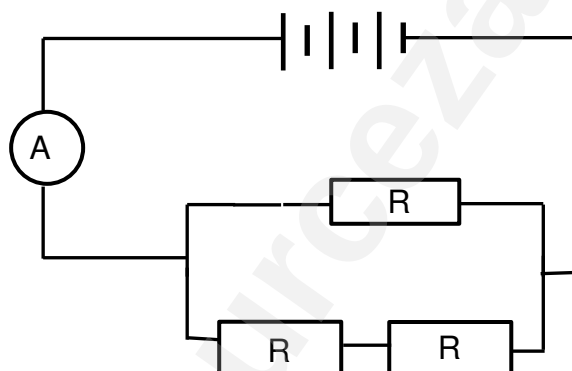
(4)
[11]

QUESTION 7 ELECTRIC CIRCUITS

The photograph shows a convector heater designed for use in the home. It operates by air flowing through the heater and passing over its heating elements. The heater contains three identical resistors and two switches.

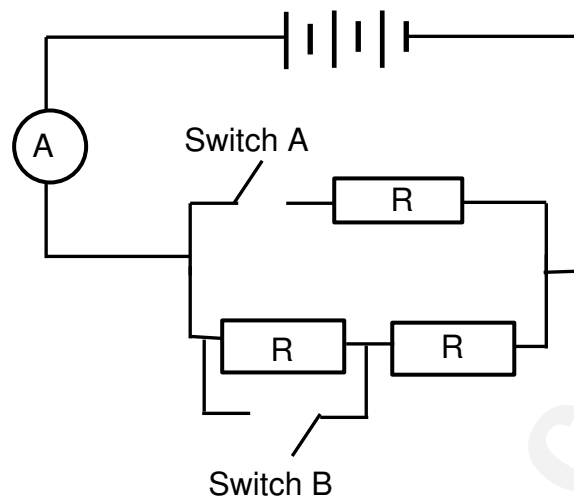


- 7.1 Consider the circuit, drawn below without the switches. The power source has internal resistance. The *emf* of this circuit is 220 V and the $V_{\text{lost}} = 20$ V.



- 7.1.1 Define *potential difference*. (2)
- 7.1.2 Define *emf*. (2)
- 7.1.3 Calculate the external resistance of the circuit if the resistance of each resistor is $20\ \Omega$. (3)
- 7.1.4 Calculate the reading on the ammeter. (4)
- 7.1.5 Calculate the internal resistance of the power source. (3)
- 7.1.6 Calculate the energy consumed by the heater over 8 hours. (4)
- 7.1.7 Calculate the cost of running the heater for the period of time above if the cost of 1 kWh = R 2,09. (4)

7.2 Consider the same circuit, redrawn below with the switches.



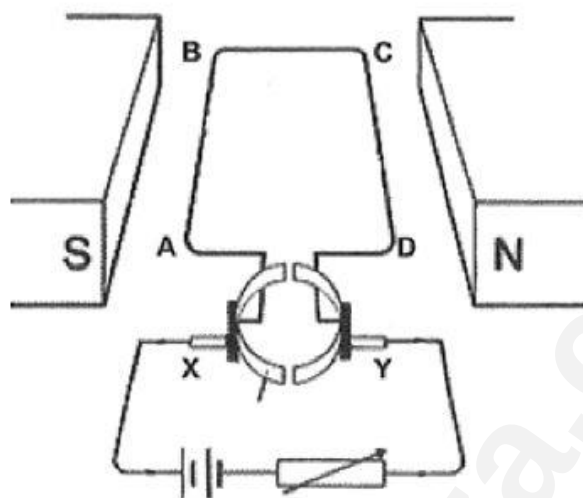
The table below gives three possible combinations of the two switches. Complete the table (questions 7.2.1 – 7.2.2) to show the total circuit resistance for each switch combination.

Switch combinations	Total circuit resistance
A open. B closed.	R
A open. B open.	7.2.1
A closed. B closed.	7.2.2

(2)
 [24]

QUESTION 8 ELECTRODYNAMICS

8.1 Consider the motor shown below.

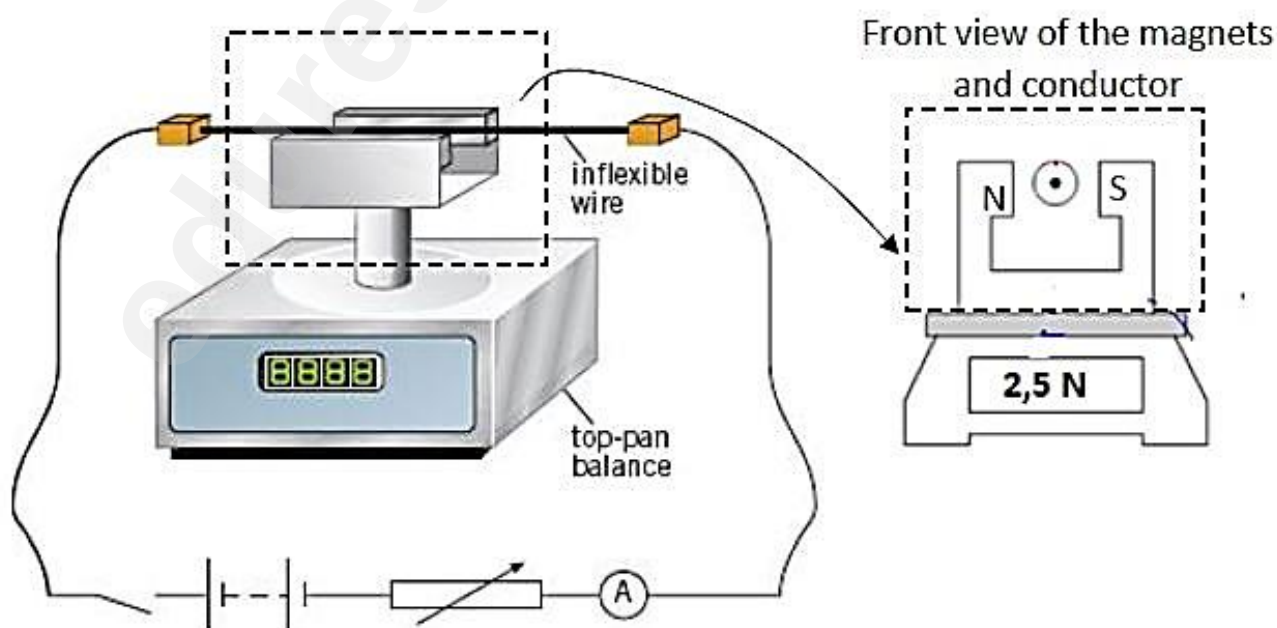


8.1.1 Give two reasons why this is a DC motor. (2)

8.1.2 What energy conversion occurs in this device? (2)

8.1.3 In which direction will the armature rotate when viewed from the front.
Answer CLOCKWISE or ANTICLOCKWISE only. (1)

8.2 The Grade 12 students are studying the effect of magnets on conducting wire. They set up the following apparatus:



In the experiment, a 5 cm length of wire is suspended between two magnets. The apparatus rests on a scale that is calibrated in Newton's. Before the circuit is connected, the weight of the apparatus on the scale is 2,5 N. When the switch is closed, the ammeter reading is 4 A and the reading on the scale changes to 2,516 N.

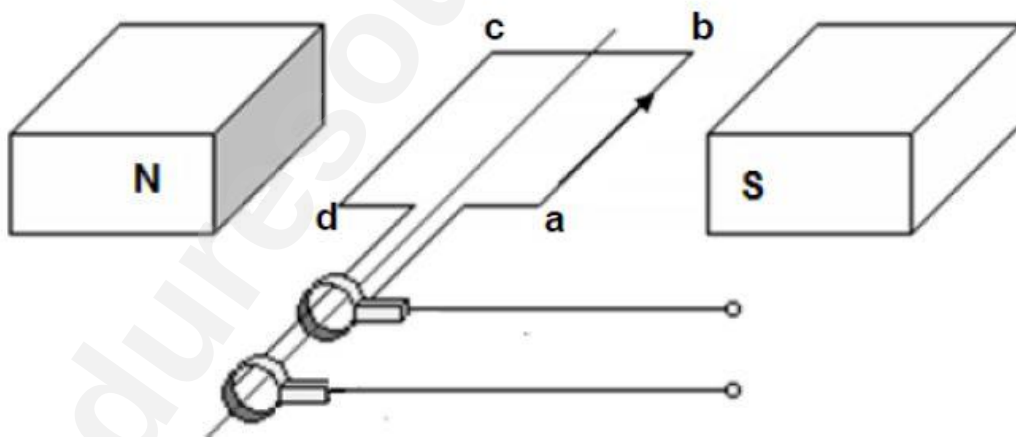
8.2.1 In which direction does the conducting wire experience a force? (2)

8.2.2 State the law of physics that is illustrated by the increase in the reading. Use it to explain why the reading increased. (3)

8.2.3 Calculate the strength of the magnetic force that was exerted on the wire. (2)

8.2.4 Write down an appropriate equation from your data sheet that could be used to determine the magnetic field density in the experiment. (1)

8.3 The output potential difference of an AC generator is **100 V at 20 Hz**. A simplified diagram of the generator is shown below. The direction of the current in the coil is from **a to b** when the circuit is closed.



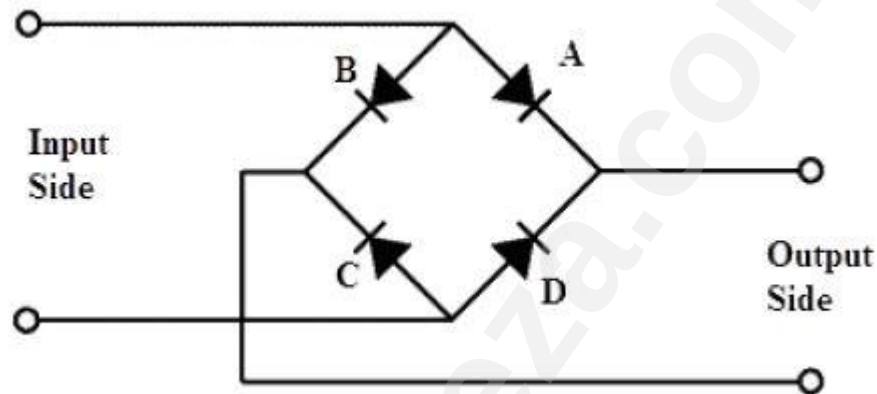
8.3.1 Use the equation for magnetic flux provided on the data sheet to explain whether the magnetic flux through the coil is maximum or zero in the horizontal position shown. (2)

8.3.2 In which direction is the coil rotating, as viewed from the slip rings? Write only CLOCKWISE or ANTICLOCKWISE. (1)

8.3.3 Define *Faraday's Law*. (2)

8.3.4 Starting from the position shown in the diagram, sketch a graph of the output *emf* versus time when the coil completes TWO full cycles. On the graph, clearly indicate the maximum *emf* (100 V) and the time taken to complete the two cycles. (4)

8.3.5 The frequency is now changed from 20 Hz to **10 Hz** and the output *emf* is recorded after passing through a **bridge rectifier**, depicted below.

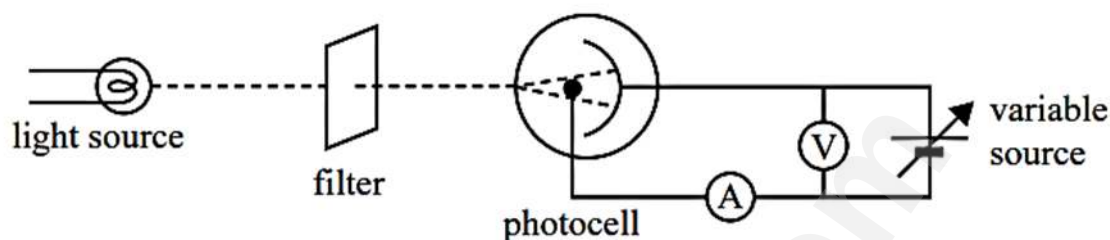


- Name the component labelled A, B, C and D in the bridge rectifier. (1)
- What is the purpose of a bridge rectifier in an AC circuit? (2)
- On the same set of axes as used in 8.3.4, use a dotted line or a different colour to show the COMBINED effect of these two changes on the graph of output *emf* vs time. (3)

[28]

QUESTION 9 PHOTONS AND ELECTRONS

Students are studying the photoelectric effect using the apparatus shown in the diagram below.



The table below shows the results the students obtained for the maximum kinetic energy ($E_{k \text{ max}}$) of the emitted photoelectrons versus the frequency of the incoming light.

Frequency of incident radiation ($\times 10^{15} \text{ s}^{-1}$)	Kinetic energy of ejected electrons ($\times 10^{-19} \text{ J}$)
1,0	0 (none emitted)
2,0	5,9
2,5	9,21
3,0	12,52
3,5	15,84
4,0	19,15

- 9.1 Define *threshold frequency*. (2)
- 9.2 Draw a graph on the graph paper on the ANSWER SHEET using the data from the table. Complete the missing information on the axes. (5)
- 9.3 Using **only data FROM THE GRAPH**, determine the values the students would have obtained for:
- 9.3.1 Planck's constant, h . Include a unit in your answer. (4)
- 9.3.2 the maximum wavelength of light that would cause the emission of photoelectrons. (3)
- 9.3.3 the work function of the metal of the photocell.
GIVE YOUR ANSWER IN eV. (3)

[17]