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TRIALS EXAMINATION 2016

GRADE 12

Physical Science – Paper 1

Examiner: K Mari

Time: 3 Hours

Moderator: H Nund

Marks: 200

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of:

- 15 pages.
- 13 page question paper.
- 2 Pages data sheet.

Please make sure your question paper is complete.

2. Read the questions carefully.
3. Do question 1 (multiple choice) on the inside of the cover sheet of your answer booklet.
4. Start each question on a new page.
5. Show all working were necessary.
6. It is in your own interest to write legibly and to set your work out neatly.
7. You may use a non – programmable calculator.
8. Answer all questions.

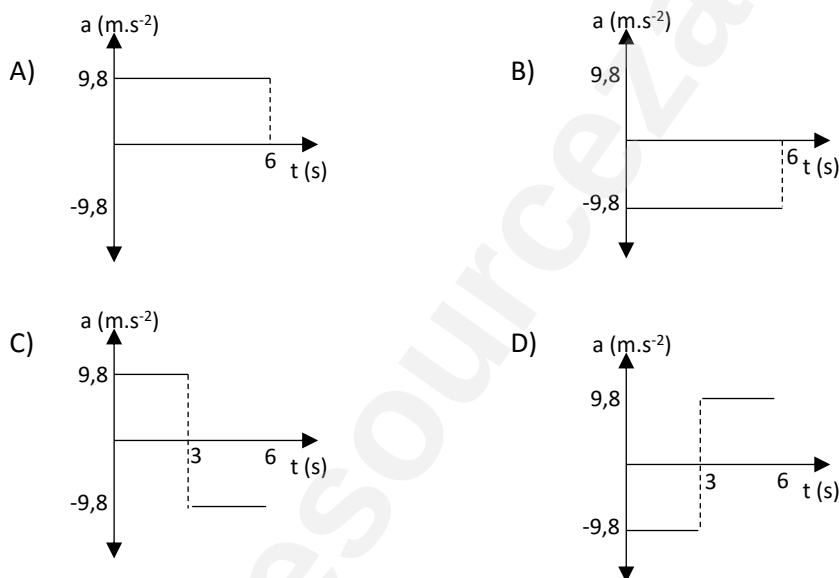
Question 1

There are four alternatives given for each question. Choose the most correct alternative and cross the appropriate letter on the answer sheet provided on the inside of the cover page.

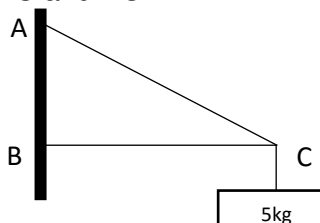
1.1 The formula $\Delta x = v_i \Delta t$ describes the linear motion of an object

- A) acceleration uniformly from rest
- B) accelerating uniformly from some initial velocity
- C) moving with constant velocity
- D) which is at rest

1.2 Which one of the acceleration-time graphs best represents the motion of a stone which is projected upwards and is then caught at the same height after 6s? Take up as the positive (+) reference direction.



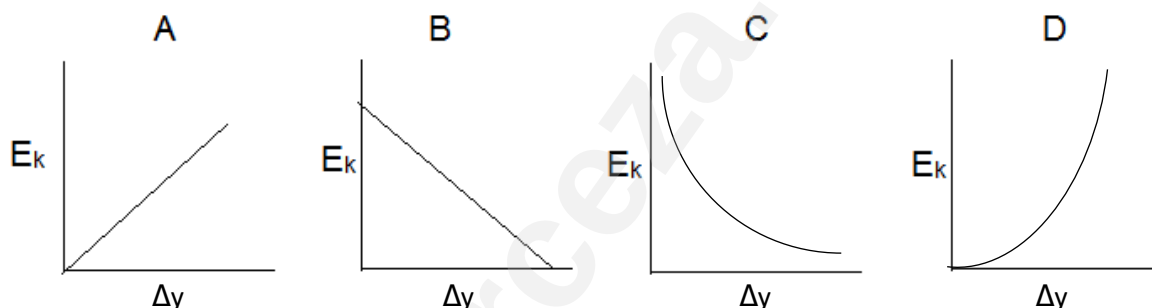
1.3 The diagram below represents a 5 kg object held at rest, away from a vertical wall, AB, by two struts, BC and AC.



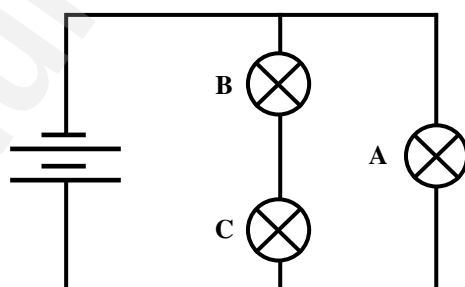
Which statement about the forces acting in this situation is true?

- A The vertical component of the force strut AC exerts on C is 49N.
- B The tension in strut AC must be 49N.
- C The nett force acting on the system is 49N.
- D The tension in strut BC is 49N.

- 1.4 A satellite orbits the Earth at a height above the surface where the gravitational force is a factor four less than at the surface of the earth. If the radius of the earth is R , the height of the satellite above the surface of the earth is...
- A) $2R$ B) R C) $R/2$ D) $R/4$
- 1.5 A car A has half the mass of a truck B. The vehicles are initially at rest. The same net force is now applied for the same time to both A and B. How will the momenta of A and B now compare? If the momentum of car A is p , the momentum of truck B will be
- A) $p/2$ B) p C) $2p$ D) $4p$
- 1.6 A stone falls from rest from the top of a building. Ignore air resistance. Which of the following graphs best represents the relationship between the kinetic energy (E_k) and the displacement (Δy) of the stone? Displacement is measured downwards from the point of release.

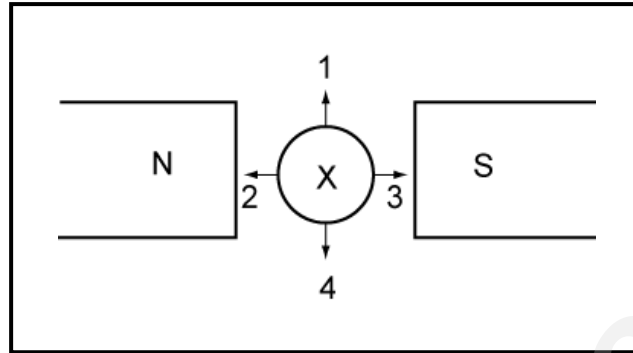


- 1.7 When n resistances each of value r are connected in parallel, then resultant resistance is x . When these n resistances are connected in series, total resistance is:
- A. nx B) $rn x$ C) $\frac{x}{n}$ D) $n^2 x$
- 1.8 In the diagram below, the three bulbs, A, B, and C, are all identical. Which statement concerning the brightness of the bulbs is true?



- A) B and C are equally bright but dimmer than A.
- B) B and C are equally bright but brighter than A.
- C) A is brighter than B, which in turn is brighter than C.
- D) The three bulbs are equally bright.

- 1.9 A current-carrying conductor is placed in a magnetic field. The current flows into the page.



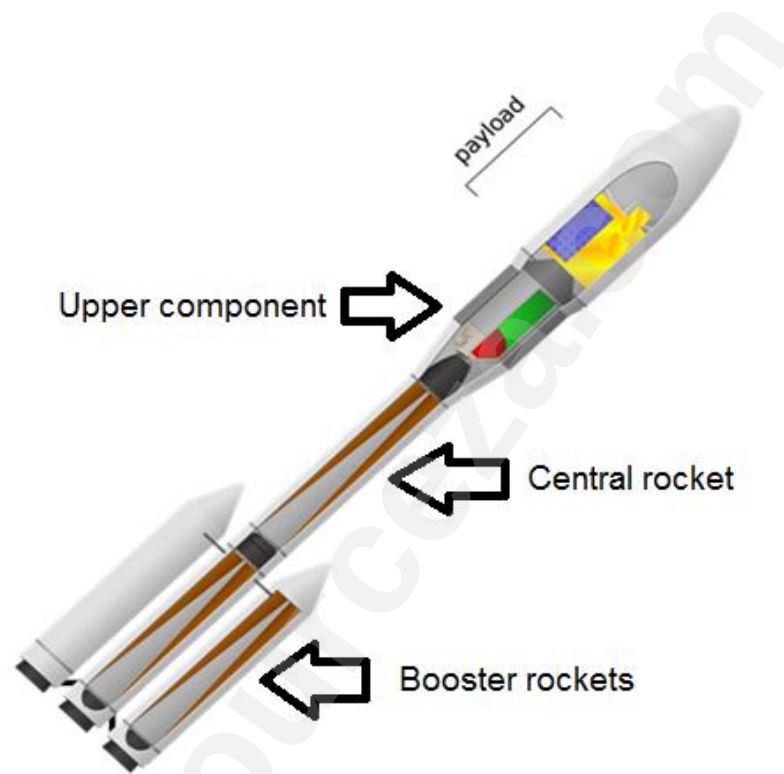
In which direction will the conductor experience a force?

- A) 1 B) 2 C) 3 D) 4
- 1.10 Radiation of a given wavelength causes electrons to be emitted from the surface of metal 1 but not from the surface of metal 2. Why could this be?
- A) Metal 1 has a greater work function than metal 2 has.
- B) Metal 1 has a smaller work function than metal 2 has.
- C) The energy of a photon striking metal 1 is greater than the energy of a photon striking metal 2.
- D) The intensity of the radiation, radiated on Metal 1 is greater than the intensity of the radiation radiated on Metal 2.

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Question 2

The **International Space Station (ISS)** is a habitable [artificial satellite](#), in [low Earth orbit](#). On the 7th of July 2016, [Kathleen Rubins](#), [Anatolilvanishin](#) and [Takuya Onishi](#) departed on the Soyuz-FG rocket to be a part of the crew of the 48th expedition to the ISS. A diagram of this rocket is shown below.



The launch occurs in 3 stages:

Stage 1: At time of launch, the Soyuz rocket has a mass 305 tons including all components and fuel (1 ton = 1 000 kg). Booster rockets and a central rocket are all ignited at the same time, forcing the rocket to launch skyward. After 120 s all the fuel has been burnt up and the four booster rockets are discarded. This occurs at an altitude of 40 000 m. At the end of stage 1 the rocket is travelling at $666,93 \text{ m}\cdot\text{s}^{-1}$

Stage 2: The central rocket continues to fire. At a height of 170 km this rocket is then also discarded. During this stage the rocket is accelerating at $0,6 \text{ m}\cdot\text{s}^{-2}$ upwards.

Stage 3: The engines of the upper stage are ignited and the rocket travels for a further 1 minute reaching a velocity of $891,14 \text{ m}\cdot\text{s}^{-1}$. The payload (capsule carrying the astronauts), with a mass of 6900 kg is released and heads for the ISS.

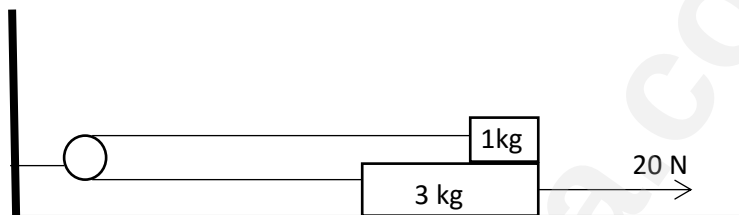
Assuming a constant acceleration in each stage, answer the following questions

- 2.1 Answer the following questions about Stage 1 of the rocket's launch.
- 2.1.1 Define acceleration. (2)
 - 2.1.2 Given that the rocket starts from rest, show that the magnitude of the acceleration of the rocket is $5,56 \text{ m.s}^{-2}$. (3)
 - 2.1.3 State Newton's third law. (3)
 - 2.1.4 Identify and state the action-reaction pair of forces during lift off. (2)
 - 2.1.5 Calculate the net force acting on the rocket during lift-off. (4)
- 2.2 Answer the following questions about Stage 2 of the rocket's launch. Assume acceleration due to gravity is $9,8 \text{ m.s}^{-2}$.
- 2.2.1 What is the magnitude of the velocity of the discarded boosters at their highest point? (1)
 - 2.2.2 What is the acceleration of the discarded boosters at their highest point? (2)
 - 2.2.3 Calculate the highest altitude above the ground the boosters reach. (4)
 - 2.2.4 Calculate the time take for the 4 booster rockets to hit the ground from the time they are discarded. (5)
- 2.3 Answer the following questions about Stage 3 of the rocket's launch.
- 2.3.1 Calculate the total time the rocket has been in the air when the central rocket is discarded. (5)
 - 2.3.2 Calculate the maximum altitude above the ground the rocket reaches before the payload is released, to the nearest km. (6)
- 2.4 Draw a velocity-time sketch graph of the 3 stages of the rockets motion. Show all relevant velocity and time values. (6)

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Question 3

A horizontal force of 20 N is applied to a 3 kg block situated on a frictionless surface as shown. A second 1kg block is placed on the rough upper surface of the first block. The two blocks are joined by an inextensible string of negligible mass running through a frictionless pulley. The frictional force between the two blocks is 2 N while they are moving. Consider the tension in the string, joining the two blocks to be T .



- 3.1 Draw a labelled force diagram of the 3 kg block showing all the horizontal forces acting on it while it is moving. (4)
- 3.2 Write an expression to show the net force acting on the 3kg block. (3)
- 3.3 Write an expression to show the net force acting on the 1kg block. (3)
- 3.4 Hence determine the magnitude of the acceleration of the 3 kg block. (4)

[14]**Question 4**

Two students are standing in a lift that is accelerating uniformly, upwards at 2 m.s^{-2} . They recall a statement in lectures about standing on a bathroom scale in the lift and how the readings will change.

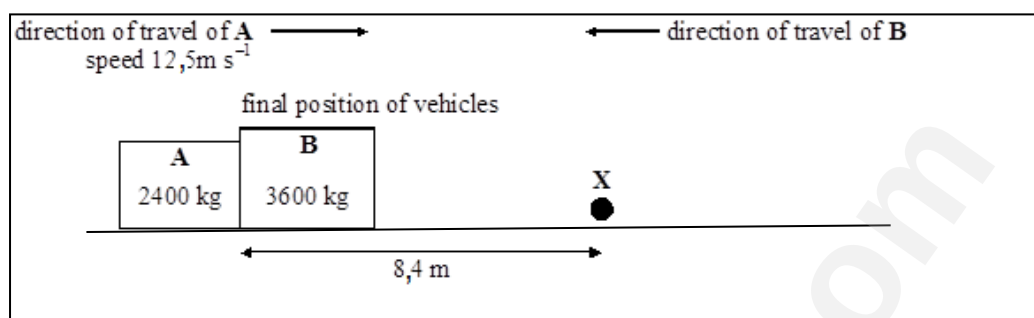
The students have masses of 81 kg and 78 kg.

- 4.1 Draw a labelled free body diagram to represent the forces acting on the 78 kg student, who is standing on the bathroom scale, while the lift accelerates upwards. (4)
- 4.2 Calculate the magnitude of the resultant force that acts on the 78 kg student. (3)
- 4.3 Calculate the magnitude of the force exerted by the scale on the 78 kg student. (6)
- 4.4 Using one of Newton's Laws, name this law and explain why the magnitude of the force exerted by the student on the scale is equal in magnitude to the answer in the previous question, 4.3. (4)

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Question 5

The diagram below shows a sketch drawn by an accident investigator following a head-on collision between two vehicles, A and B which collide at point X.



From the skid marks and debris on the road the investigator knows that the collision took place at the point marked **X**. The vehicles locked together on impact and vehicle **A** was pushed backwards a distance of 8,4 m.

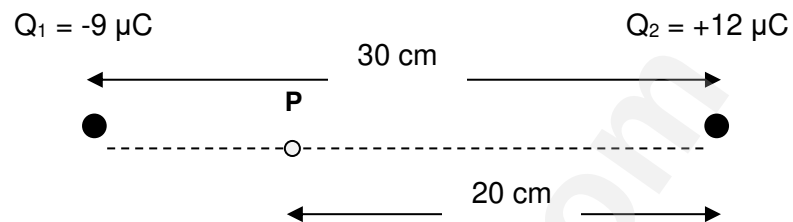
For the road conditions and vehicle masses the average frictional force between the road and the vehicles immediately after the collision was known to be 7500 N. This was the force which caused the vehicles to come to rest.

- 5.1 State the law of conservation of Linear Momentum. (3)
- 5.2 Calculate the work done against friction in bringing the vehicles to rest. (4)
- 5.3 Determine the speed of the interlocked vehicles immediately after impact. (4)
- 5.4 Vehicle **A** was known to be moving at $12,5 \text{ m.s}^{-1}$ just before the impact. Calculate the velocity of vehicle **B** just before impact. (5)
- 5.5 The drivers of both vehicles have the same mass. State and explain which driver is likely to experience the greater force during the impact. (4)
- 5.6 Is the collision elastic or inelastic? Use a calculation to justify your answer. (4)

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Question 6

Two point charges, Q_1 and Q_2 , a distance 30 cm apart, are shown below. The charge on Q_1 is $-9 \mu\text{C}$ and the charge on Q_2 is $+12 \mu\text{C}$.

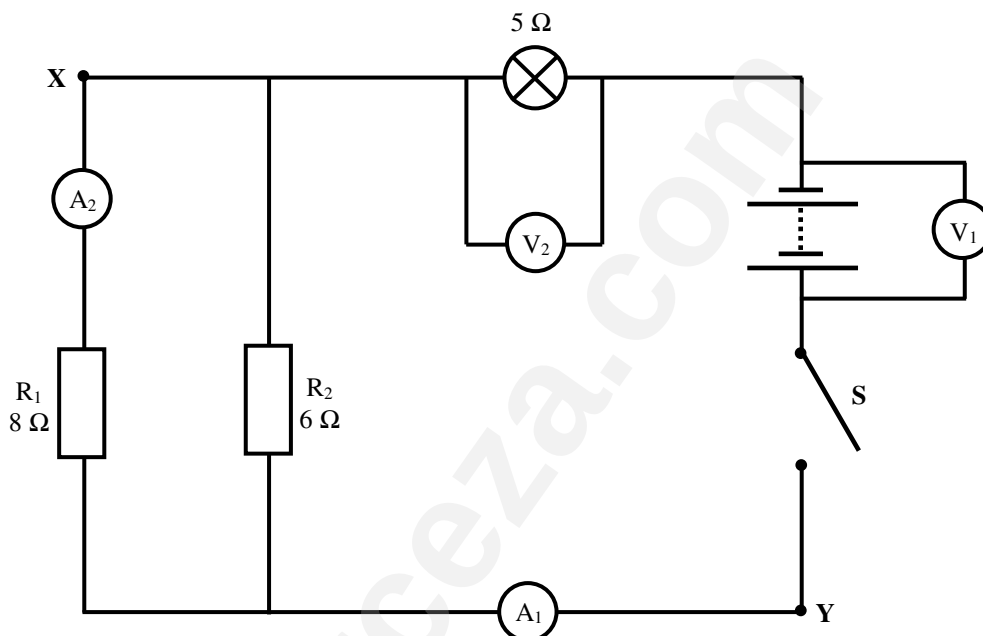


- 6.1 Define the magnitude of the electric field at a point in space. (2)
- 6.2 Draw the electric field pattern due to these two charges. (3)
- 6.3 Calculate the net electric field at point **P** situated 20 cm from Q_2 . (8)

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Question 7

The battery in the circuit below has an internal resistance of $2\ \Omega$. The reading on voltmeter V_1 changes from 22 V to $19,5\text{ V}$ when the switch S is closed. The resistances of R_1 and the bulb are $8\ \Omega$ and $5\ \Omega$ respectively and that of R_2 is unknown. The resistances of the ammeters and connecting wires are negligible and the resistance of the voltmeters are very high.



For each of the following questions, assume switch S is closed.

- 7.1 Define the term *emf*. (2)
- 7.2 Calculate the reading on ammeter A_1 . (4)
- 7.3 Calculate the reading on voltmeter V_2 . (3)
- 7.4 Calculate the reading on ammeter A_2 . (4)
- 7.5 Determine the energy (in kilojoules) dissipated in the bulb if the circuit is run at constant current for 3 hours. (4)
- 7.6 If a voltmeter is connected between points X and Y , what would the voltmeter read? (1)
- 7.7 A connecting wire of negligible resistance is connected between points X and Y . How does this affect the brightness of the bulb? Explain fully, with reference to relevant equation(s). (5)

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Question 8

Electric motors and electric generators both require an active magnetic field and a coil which can rotate.

8.1 What is the motor effect? (2)

8.2 How does one increase the number of rotations that the coil can make per second which can cause the motor to “burn out”? Give **TWO** different possibilities. (4)

Electric motors have many household applications, e.g. a fan heater. Consider the following advertisement for an electric heater. Read the advertisement carefully.

COMPACT HEATER BIG ON HEAT PRODUCTION

The new compact heater is the latest development in heating technology. Although it is far smaller than most other domestic heaters, it is exceptionally efficient, economical and safe.

IT HEATS A ROOM IN MINUTES

A powerful fan draws in air across a thermistor heating element. This heating element automatically reduces its power consumption as the temperature increases.

The heater has a maximum output of 1000 W and operates from a 220 V AC supply.

8.3 The advertisement says that the power consumption of the heater decreases as the temperature increases. Using a formula, explain what happens to the current through the heater as the temperature increases. (3)

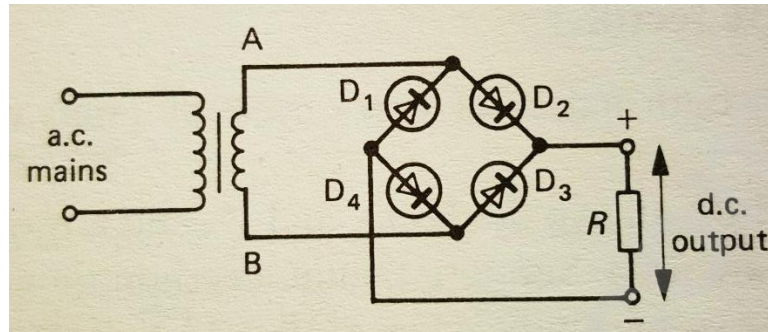
8.4 What happens to the resistance of the heater as the temperature increases? (1)

8.5 Since the maximum power of the heater is 1000 W, what rating fuse would you recommend as a suitable safety precaution? Support your answer with a simple calculation. (4)

[14]

Question 9

Consider the diagram below.



This is a transformer connected to a bridge full-wave rectifier.

- 9.1 What type of transformer is this? (1)
- 9.2 If the a.c mains produce 0,5A at 240V the secondary voltage becomes 24V, what does the secondary current read? (3)
- 9.3 The above transformer is said to be only approximately 60% efficient, using that fact calculate the output power of the transformer. (3)
- 9.4 A rectifier is 'changes' alternating current into direct current, how does it do that? (2)
- 9.5.1 If A is positive with respect to B during the first half-cycle, trace the path of the current through the circuit. Use the labels provided on the circuit to label the pathway. (2)
- 9.5.2 During the next half-cycle when B is positive, trace the pathway using the same labels as above. (2)
- 9.6 What do you notice about the flow of current through resistor R throughout one complete cycle. (1)

[14]

Question 10

10.1 Visible light with a wavelength of 500 nm shines on a potassium metal surface and ejects electrons with a maximum speed of $287 \times 10^3 \text{ m.s}^{-1}$.

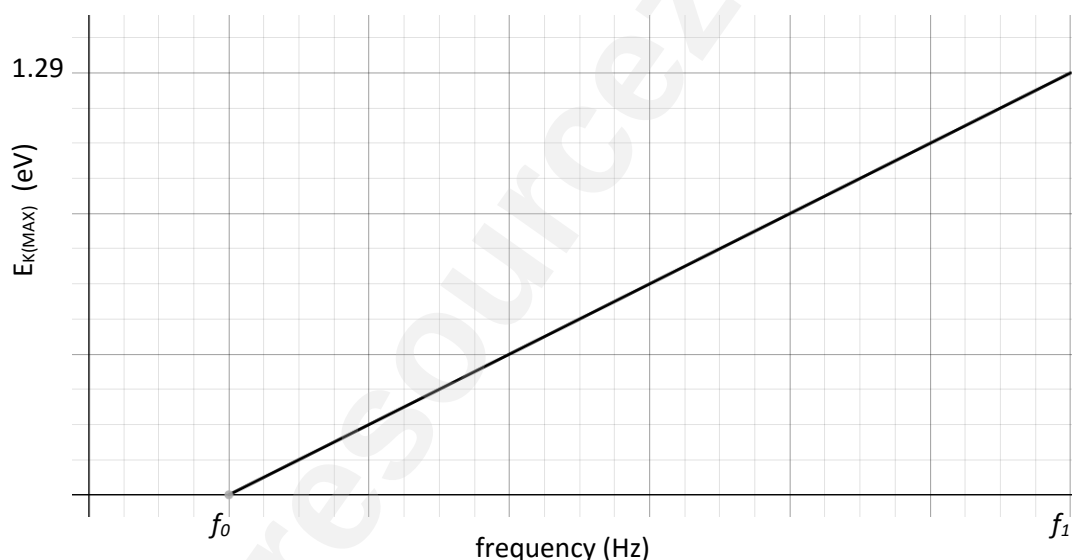
10.1.1 Name the process that occurs when light shines on a metal and electrons are ejected. (1)

10.1.2 Calculate the maximum kinetic energy of the ejected electrons. (3)

10.1.3 Define *work function* (W_0) (2)

10.1.4 Calculate the work function of potassium metal. (4)

10.2 Electromagnetic radiation of various frequencies is now shone onto a calcium metal surface. The work function of calcium metal is 2.71 eV. A graph (not to scale) showing the relationship between the $E_{K(\text{max})}$ of the ejected electrons and the frequency of the electromagnetic radiation is given below.



10.2.1 Define *threshold (cut-off) frequency* (f_0). (2)

10.2.2 Calculate the threshold frequency (f_0) of calcium metal. (3)

10.2.3 Determine the frequency of the electromagnetic radiation at f_1 . (3)

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

TABLE 1 PHYSICAL CONSTANTS

NAME	SYMBOL	VALUE
Approximate magnitude of acceleration due to gravity	g	$9,8 \text{ m}\cdot\text{s}^{-2}$
Speed of light in a vacuum	c	$3,0 \times 10^8 \text{ m}\cdot\text{s}^{-1}$
Gravitational constant	G	$6,7 \times 10^{-11} \text{ N}\cdot\text{m}^2\cdot\text{kg}^{-2}$
Coulomb's constant	k	$9,0 \times 10^9 \text{ N}\cdot\text{m}^2\cdot\text{C}^{-2}$
Magnitude of charge on electron	e	$1,6 \times 10^{-19} \text{ C}$
Mass of an electron	m_e	$9,1 \times 10^{-31} \text{ kg}$
Planck's constant	h	$6,6 \times 10^{-34} \text{ J}\cdot\text{s}$
Standard pressure	$p^\ominus$	$1,013 \times 10^5 \text{ Pa}$
Molar gas volume at STP	V_m	$22,4 \text{ dm}^3\cdot\text{mol}^{-1}$
Standard temperature	$T^\ominus$	273 K
Avogadro's number	N_A	$6,02 \times 10^{23} \text{ mol}^{-1}$

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

$p = mv$	$F_{net} = \frac{\Delta p}{\Delta t}$	$F_{net}\Delta t = m\Delta v$
$F_{net} = ma$	$w = F_g = mg$	$F_f^{max} = \mu F_N$

WORK, ENERGY AND POWER

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

GRAVITATIONAL AND ELECTRIC FIELDS

$F = G \frac{m_1 m_2}{r^2}$	$g = G \frac{M_{planet}}{(R_{planet})^2}$
$F = k \frac{q_1 q_2}{r^2}$	$E = \frac{F}{q}$
	$E = \frac{kQ}{r^2}$

ELECTRIC CIRCUITS

$I = \frac{q}{t}$	$V = \frac{W}{Q}$
$R = \frac{V}{I}$	$emf = I(R_{ext} + r)$
$R_T = R_1 + R_2 + \dots$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$
$W = Pt$	$P = VI = I^2 R = \frac{V^2}{R}$

ELECTRODYNAMICS

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

PHOTONS AND ELECTRONS

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

TABLE 3 CHEMISTRY FORMULAE

$n = \frac{m}{M}$	$E_{cell}^\theta = E_{cathode}^\theta - E_{anode}^\theta$ $E_{cell}^\theta = E_{oxidising\ agent}^\theta - E_{reducing\ agent}^\theta$
$V = nV_m$ $c = \frac{n}{V}$	$K_w = [H_3O^+][OH^-]$ at 298 K