**Coimisiún na Scrúduithe Stáit**
State Examinations Commission

# Leaving Certificate 2015

# Marking Scheme

# Physics

## Ordinary Level

**Note to teachers and students on the use of published marking schemes**

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

**Future Marking Schemes**

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

**General Guidelines**

**In considering this marking scheme the following points should be noted.**

1. In many instances only key words are given, words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.

2. Marks shown in brackets represent marks awarded for partial answers as indicated in the scheme.

3. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable.

4. Answers that are separated by a double solidus, //, are answers which are mutually exclusive. A partial answer from one side of the // may not be taken in conjunction with a partial answer from the other side.

5. The descriptions, methods and definitions in the scheme are **not** exhaustive and alternative valid answers are acceptable. Marks for a description may be obtained from a relevant diagram, depending on the context.

6. Each time an arithmetical slip occurs in a calculation, one mark is deducted.

7. The context and the manner in which the question is asked and the number of marks assigned to the answer in the examination paper, determine the detail required in any question. Therefore, in any instance, it may vary from year to year.

**Section A** **(120 marks)**

**Three questions to be answered.**

**Question 1 40 marks**

**A student carried out an experiment to investigate the relationship between force and acceleration by applying a force to a body and measuring the resulting acceleration. The table shows measurements recorded during the experiment.**

| **Force (N)** | **0.5** | **1.0** | **1.5** | **2.0** | **2.5** | **3.0** | **3.5** |
|---|---|---|---|---|---|---|---|
| **Acceleration (m $s^{-2}$)** | **0.1** | **0.2** | **0.3** | **0.4** | **0.5** | **0.6** | **0.7** |

(*i*) **Draw a labelled diagram of the apparatus used in the experiment.** 3×3

diagram to show:

trolley and runway // air track and rider 3

means of applying force correctly 3

timer e.g. ticker timer / photogate(s) / motion sensor 3

**NOTE:** no labels, deduct 2

accept valid alternatives, e.g. data logging methods, which fit the scheme

(*ii*) **State what measurements were taken during the experiment.** 6+3

force // distance / velocity / acceleration // time two correct 6+3

one correct (6)

(*iii*) **How were the effects of friction reduced in this experiment?** 6 or 3

slant/clean the runway / oil (the trolley) wheels / frictionless wheels 6

partial answer (3)

this may be inferred from the diagram in (***i***)

(*iv*) **Plot a graph, on graph paper, of the acceleration against the force.** 4×3

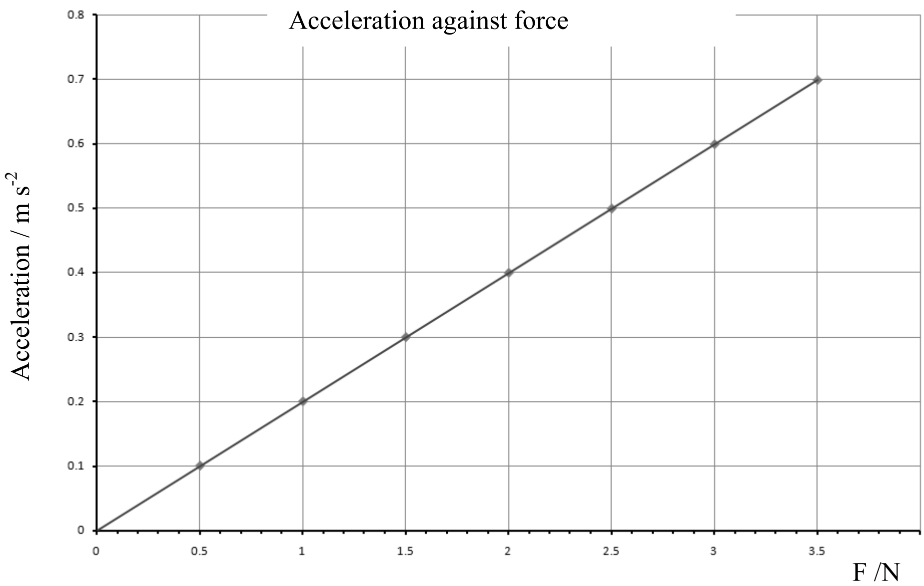
labelled axes 3

three points plotted correctly 3

three more points plotted correctly 3

straight line with good fit 3

if graph paper is not used maximum mark 3×3




(*v*) **What does your graph tell you about the relationship between the acceleration of the body and the force applied to it?** 4 or 2

(they are ) proportional / $\propto$ / straight line through the origin 4

partial answer e.g. inversely proportional (2)

**Question 2 40 marks**

**During an experiment to measure the specific latent heat of vaporisation of water, cold water was placed in an insulated copper calorimeter. Dry steam was passed into the water, causing the temperature of the calorimeter and water to rise. The following are some of the measurements that were recorded.**

**Mass of calorimeter + water..................................................................90.7 g**
**Mass of calorimeter + water + steam ....................................................92.3 g**

| | | | |
|---|---|---|---|
| (*i*) | **Draw a labelled diagram of the apparatus used in the experiment.** | | **6+3** |
| | water in calorimeter, means of adding steam, thermometer, mass balance, insulation, steam trap | any two | 6+3 |
| | | any one | (6) |
| | incorrect experiment, maximum 6 marks | | |
| | **NOTE:** no labels, deduct 2 | | |
| | accept valid alternatives | | |
| (*ii*) | **How was the steam dried?** | | **6 or 3** |
| | steam trap | | 6 |
| | partial answer | | (3) |
| (*iii*) | **What other measurements should be taken during this experiment?** | | **6+3** |
| | mass of calorimeter, initial temperature, final temperature, mass of steam, mass of water | any two | 6+3 |
| | | any one | (6) |
| | rise in temperature | | (6) |
| | partial answer e.g. temperature | | (3) |
| (*iv*) | **Calculate the mass of steam used.** | | **3** |
| | (92.3 – 90.7 = ) 1.6 (g) | | 3 |
| (*v*) | **Calculate the latent heat released when the steam condensed.** | | **3× 3** |
| | 3680 (J ) | | 3×3 |
| | two quantities correctly substituted into equation e.g. $0.0016 \times 2.3 \times 10^6$ | | (3×3-1) |
| | one quantity correctly substituted into equation | | (2×3) |
| | partial answer e.g. ($E$=) $ml$ / other heat equation | | (3) |
| (*vi*) | **State one safety precaution required for this experiment.** | | **4 or 2** |
| | gloves / tongs / safety glasses / etc. | | 4 |
| | partial answer | | (2) |
| | may be inferred from the diagram in (***i***) | | |

**Question 3 40 marks**

**In an experiment to measure the focal length of a concave mirror, a student placed an object in front of the mirror so that a real image was formed. The student repeated the experiment by placing the object at different positions.**

**The table shows the data recorded by the student.**

| ***u*** **(cm)** | **20** | **25** | **30** | **60** |
|---|---|---|---|---|
| ***v*** **(cm)** | **60** | **38** | **30** | **19.5** |

**(*i*) Draw a labelled diagram showing the arrangement of the apparatus used** **6+2×3**

labelled diagram to show

| | | |
|---|---|---|
| object, concave mirror, screen / search pin | any two | 6+3 |
| | any one | (6) |
| correct arrangement | | 3 |
| approximate method maximum 9 marks | | |

**NOTE:** no labels, deduct 2
accept valid alternatives

**(*ii*) How was the position of the image located?** **6 or 3**

move screen / object / mirror /pin // sharpest image formed // there is no parallax — 6

partial answer — (3)

**(*iii*) Show the distances *u* and *v* on your diagram.** **2×3**

distance from the object/crosswire to the mirror shown as $u$ — 3

distance from the image/screen to the mirror shown as $v$ — 3

partial answer e.g. reversed — (3)

**(*iv*) Calculate the value of *f*, the focal length of the mirror.** **4×3**

(average value for $f$ =) 15 ±0.1 (cm) — 4×3

$f$ calculated once — (3×3)

$\frac{1}{f} = \frac{1}{20} + \frac{1}{60} = 0.067 \pm 0.001$ — (3×3-1)

correct substitution for $u$ and $v$ once — (2×3)

detail e.g. $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ — (3)

**(*v*) Why did the student repeat the experiment?** **4 or 2**

greater accuracy / more reliable result / minimise errors, to get an average etc. — 4

partial answer — (2)

**Question 4 40 marks**

**In an experiment to find the resistivity of the material of a wire, a student took a sample of the wire and measured its length *l*, diameter *d*, and resistance *R*.**

(*i*) **Describe how the student found the resistance of the wire.** **6 or 3**

ohmmeter / (digital) multimeter / measure $V$ and $I$ and hence determine $R$

/ $R = \frac{V}{I}$ 6

partial answer e.g. measure $I$ / ammeter / meter (3)

(*ii*) **What instrument did the student use to measure the diameter of the wire?** **6 or 3**

micrometer // digital/vernier callipers 6

partial answer e.g. callipers (3)

**The table shows the measurements recorded by the student.**

| | | | |
|---|---|---|---|
| ***R* (Ω)** | **30** | | |
| **cm)** | **80** | | |
| **(mm)** | **0.2 1** | **0.2 6** | **0.2 2** |

(*iii*) **Use the data to calculate the cross-sectional area of the wire.** **4×3**

$A = 0.042 \pm 0.001$ (mm$^2$) 4×3

$A = \pi(0.115)^2$ (3×3)

average $d = 0.23$( mm) / $r = 0.115$ (mm) substituted into the equation (2×3)

any valid equation e.g. $A = \pi r^2$ (3)

partial answer (3)

(*iv*) **Find the resistivity of the material in the wire.** **10 or 7 or 4**

$\rho = 1.56 \pm 0.01 \times 10^{-6}$ (Ω m) 10

three quantities correctly substituted into equation / $\rho = \frac{(30)(4.1\times10^{-8})}{0.8}$ (10 – 1)

two quantities correctly substituted into equation (7)

partial answer e.g. any valid equation / $\rho = \frac{RA}{l}$ (4)

answer consistent with **(*iii*)** acceptable

(*v*) **State two precautions which should be taken in order to obtain an accurate result.** **2×3**

make sure that the wire is taut, measure length from inside of clips, measure diameter in number of places / get average diameter, etc.

two valid precautions 2×3

one valid precaution (3)

**SECTION B (280 Marks)**

**Five questions to be answered**

**Question 5 any *eight* parts 56 marks**

**Take the <u>best 8</u> from 10 parts**

(*a*) **State Newton's law of universal gravitation.** **7 or 4**

force is proportional to product of masses and is inversely proportional to square of distance between them // $F \propto \frac{m_1 m_2}{d^2}$ 7

partial answer e.g. any other of Newton's laws (4)

(*b*) **A small stone is thrown straight up from the ground with an initial speed of 20 m s$^{-1}$. Calculate the height it has reached after two seconds.** **7 or 4**

$s = 20.4$ (m) 7

partial answer e.g $s = ut + ½ at^2$. / any valid equation (4)

(*c*) **From the list below, identify (*i*) the scientist associated with the law of refraction of light and (*ii*) the scientist associated with the laws of electromagnetic induction.** **7 or 4**

(i) Snell

(ii) Faraday two correct 7

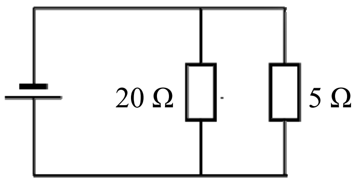
one correct (4)

(*d*) **A glass block has a critical angle of 42°. Calculate the refractive index of the glass used in the block.** **7 or 4**

n = 1.49 ± 0.05 7

partial answer e.g. any valid equation / $n = \frac{1}{\sin c}$ (4)

(*e*) **Calculate the effective resistance of the resistors shown in this circuit diagram.** **7 or 4**




$R_T = 4$ (Ω) 7

$\frac{1}{R_T} = \frac{1}{20} + \frac{1}{5}$ (7-1)

partial answer e.g. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ (4)

(*f*) **State Boyle's law.** **7 or 4**

(for a fixed mass of gas kept at a constant temperature) the pressure is inversely proportional to the volume // $PV = k$ (when $T$ and $m$ are fixed) 7

partial answer e.g. incomplete statement (4)

(*g*) **State one use of the device shown on the right.** **7 or 4**

investigating static electricity // create high voltage // stores charge 7

partial answer e.g. Van de Graaff (4)

(*h*) **Name an electronic component that has a p-n junction.** **7 or 4**

diode // transistor // LED etc. 7

partial answer e.g. TV/computer/equipment containing a p-n junction/symbol (4)

(*i*) **What is the purpose of a transformer in a mobile phone charger?** **7 or 4**

changes voltage 7

partial answer e.g. reference to voltage (4)

(*j*) **What is meant by the *half-life* of a radioactive substance?** **7 or 4**

time taken for the radioactivity to reduce by half // $T_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$ 7

partial answer (4)

**Question 6 56 marks**

**Define (*i*) potential energy and (*ii*) kinetic energy.** **9 or 6 or 3**

(*i*) energy due to position/ energy due to state / $mgh$

(*ii*) energy due to motion / $½mv^2$ two lines correct 9

one line correct (6)

partial answer e.g. definition of energy (3)

**State the principle of conservation of energy.** **3×3**

energy is not created / destroyed (but changes form) 3

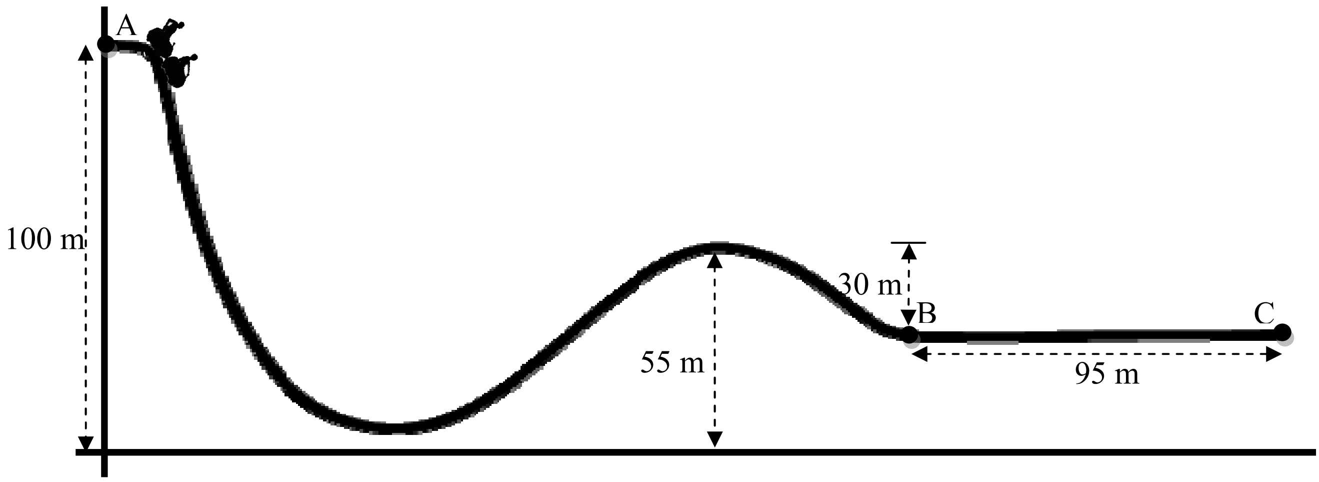
**Explain how the principle applies to a roller-coaster.**

potential energy at top of roller-coaster/ A / rest 3

converted into kinetic energy as speed increases / height decreases 3

partial answer e.g. energy at top= energy at bottom (3)

**A roller-coaster car of mass 850 kg is released from rest at point A of the track, as shown in the diagram.**




(*i*) **Calculate the difference in height between point A and point B.** **5 or 3**

75 (m) 5

partial answer e.g. one relevant step (3)

(*ii*) **Calculate the change in the potential energy of the car between A and B** **6 or 3**

624750 (J) // answer consistent with part (*i*) 6

partial answer e.g. $mgh$ / any valid equation (3)

(*iii*) **Write down the kinetic energy of the car at point B, assuming there is no friction and no air resistance. Calculate its velocity at point B.** **2(6 or 3)**

624750 ( J) // answer consistent with part (*ii*) 6

correct equation e.g. $½mv^2$ (3)

$v = 38.3$ (m s$^{-1}$) 6

$v^2 = 1470$ (3)

**The brakes are applied at point B and the car comes to a stop at point C.**

(*iv*) **Calculate the deceleration of the car between B and C.** **9 or 6 or 3**

deceleration = 7.7 ( m s$^{-2}$) 9

one correct substitution into relevant equation (6)

partial answer e.g. $v^2 = u^2 + 2as$ (3)

(*v*) **Calculate the average force required to bring the car to a stop.** **6 or 3**

$F = 6576$ (N) 6

partial answer e.g. correct equation /$F = ma$ (3)

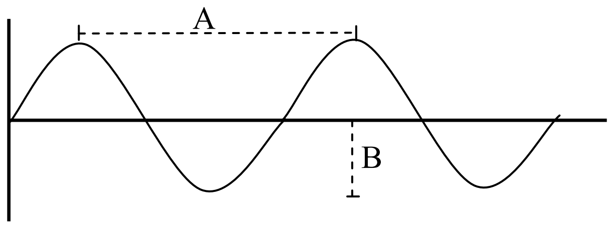
**Question 7 56 marks**

| | |
|---|---|
| **Explain the term *resonance*.** | **6 or 3** |
| transfer of energy between objects of similar natural frequency | 6 |
| partial answer e.g. example | (3) |

| | |
|---|---|
| **Describe a laboratory experiment to demonstrate resonance** | **4×3+2** |
| *apparatus*: Barton's pendulums plus detail // tuning fork and adjustable length of air | 2×3 |
| *procedure*: hang the pendulums (vertically) from a horizontal string // hold the vibrating tuning fork near air column | 3 |
| set one of the pendulums swinging // adjust the length of the air column | 3 |
| *observation/conclusion*: the pendulum of the same length also swings // at a certain length the note emitted by the tuning fork gets louder // a transfer of energy occurs / resonance occurs | 2 |

marks may be obtained from a diagram
accept valid alternatives

**The diagram shows a waveform.**




| | | |
|---|---|---|
| (*i*) | **What is length A called?** | **3** |
| | wavelength / λ | 3 |
| (*ii*) | **What is length B called?** | **3** |
| | amplitude/ height /depth | 3 |
| | partial mark if both correct but reversed | (3) |
| (*iii*) | **What is meant by the frequency of a wave?** | **6 or 3** |
| | number (of waves) per second | 6 |
| | partial answer | (3) |
| (*iv*) | **List three characteristics of a musical note.** | **6+2+1** |
| | loudness, quality, pitch | 6+2+1 |
| | any two | (6+2) |
| | any one | (6) |
| (*v*) | **What is meant by the term *natural frequency of an object*?** | **6 or 3** |
| | frequency at which it tends to vibrate (if free to do so) // frequency at which resonance occurs | 6 |
| | partial answer e.g. reference to resonance | (3) |
| (*vi*) | **The natural frequency of a stretched string is 250 Hz. Calculate the wavelength of the sound wave produced.** | **9 or 6 or 3** |
| | λ = 1.36 (m ) | 9 |
| | two correct substitutions into relevant equation e.g. $\lambda = \frac{340}{250}$ | (9-1) |
| | one correct substitution into relevant equation | (6) |
| | partial answer e.g. $c = f\lambda$ / any valid equation | (3) |

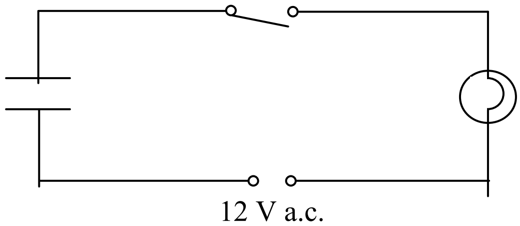
**Question 8 56 marks**

**Define capacitance. Name the unit of capacitance.** **6+3**

charge per volt / $\frac{Q}{V}$ 6

partial answer (3)

farad / F /microfarad 3




**The diagram above shows a circuit with a bulb, switch, capacitor and a 12 V a.c. power supply.**

(*i*) **What is observed when the switch is closed?** **6 or 3**
bulb lights // bulb goes on and off 6
partial answer e.g. bulb goes out (3)

(*ii*) **What would be observed if a 12 V d.c. supply were used instead of the a.c. supply?** **6 or 3**
bulb would not light 6
partial answer e.g. bulb flashes (3)

(*iii*) **What do these observations tell us about capacitors?** **6 or 3**
capacitors allow a.c. to flow but not d.c. // capacitors store charge 6
partial answer (3)

(*iv*) **The capacitor has a charge of 0.8 C when connected to the 12 V d.c. supply. Calculate its capacitance.** **3×3**
(C =) 0.07 ± 0.005 (F) 3×3
two quantities correctly substituted into equation e.g. $C = \frac{0.8}{12}$ (3×3-1)
one quantity correctly substituted into equation (2×3)
partial answer e.g. $C = \frac{Q}{V}$ / any valid equation (3)

**Describe an experiment to show that energy is stored in a charged capacitor** **4×3**
*Apparatus:* (charged) capacitor, bulb // capacitor, leads 2×3
*procedure*: connect the capacitor to the bulb // connect leads to capacitor and bring close together 3
*observation/conclusion*: bulb flashes/ leads spark /charged capacitor stores energy 3

**The photographs show a radio and a camera flash. Each of these devices makes use of a property of capacitors. Name the property used in each case.** **2(4 or 2)**
radio: tuning // smoothing 4
partial answer (2)
camera flash: storage of energy 4
partial answer (2)

**Question 9 56 marks**

**Distinguish between heat and temperature.** **9 or 6 or 3**

heat is a form of energy / heat is measured in joules
temperature is a measure of hotness / temperature is measured in °C /K

two lines correct 9
one line correct // in reverse order (6)
partial answer (3)

**The diagram shows a kettle which is filled with 500 g of water which is initially at a temperature of 20°C.**
**The heating element of the kettle has a power rating of 0.8 kW.**
**We assume all the heat is transferred to the water.**

**(*i*) Find the energy required to raise the temperature of the water to 100 °C** **4×3**

167 200 (J) 4×3
all quantities correctly substituted into relevant equation e.g. 0.5×4180×80 (4×3-1)
two quantities correctly substituted into relevant equation (3×3)
one quantity correctly substituted into relevant equation (2×3)
partial answer e.g. valid equation /$mc\Delta\theta$ // relevant calculation (3)

**(*ii*) What is the energy supplied by the element per second?** **6 or 3**

800 ( J $s^{-1}$) 6
partial answer e.g. any valid equation (3)

**(*iii*) How long will it take the kettle to heat the water to 100 °C?** **6 or 3**

209 (s) // answer consistent with ***(ii)*** 6
correct substitution into relevant equation e.g. $\frac{167200}{800}$ (6-1)
partial answer e.g. $t = \frac{Q}{P}$ (3)

**(*iv*) Why are handles of kettles often made of plastic?** **6 or 3**

plastic is a good insulator of heat // prevent burning 6
partial answer (3)

**(*v*) How is the heat transferred throughout the liquid in the kettle?** **6 or 3**

convection 6
partial answer e.g. conduction // radiation (3)

**(*vi*) Why is the heating element of a kettle made of metal?** **6 or 3**

good conductor (of heat / electricity) 6
partial answer (3)

**(*vii*) The heat source for a kettle is placed at the bottom. Suggest why this is the case.** **5 or 3**

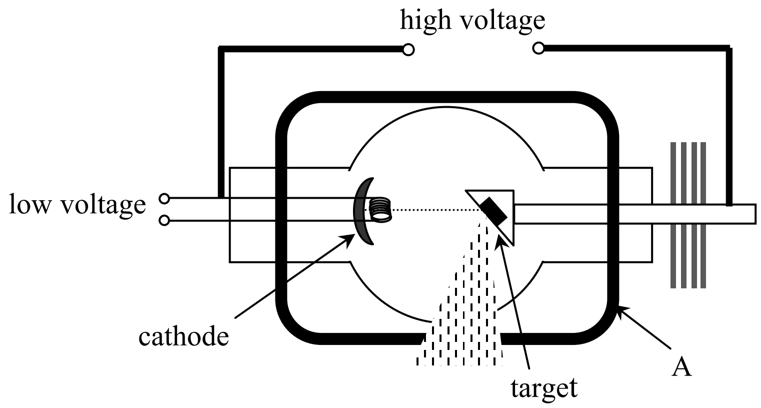
hot water rises (because it is less dense than cold water) / convection 5
partial answer (3)

**Question 10 56 marks**

**X-rays are produced when a beam of high speed electrons collides with a target in an X-ray tube, as shown below.**

**What are X-rays? State two properties of X-rays.** **6+2×3**
electromagnetic rays/waves (of high energy/frequency) 6
partial answer (3)

high energy, high frequency/ low wavelength, no mass, travel at speed of light, no charge, correct reference to penetrating power etc. any two 2×3
any one (3)




(*i*) **What process occurs at the cathode?** **6 or 3**
thermionic emission // emission of electrons 6
partial answer (3)

(*ii*) **Name a substance commonly used as the target.** **6 or 3**
tungsten / any suitable metal 6
partial answer e.g. metal (3)

(*iii*) **State the function of the part marked A.** **6 or 3**
shielding / protection 6
partial answer e.g. housing / lead (3)

(*iv*) **State one use of X-rays.** **5 or 3**
specific medical/ industrial use e.g. check for broken bones, etc. 5
partial answer e.g. property // general use such as medicine (3)

**A cathode ray tube, like the one used in the cathode ray oscilloscope, also uses a beam of high speed electrons.**

(*v*) **Draw a sketch of a cathode ray tube suitable for use in an oscilloscope.** **4×3**
anode / cathode 3
electric deflecting plates 3
(fluorescent) screen 3
(heated) filament // vacuum tube // relevant detail 3

(*vi*) **Why is a vacuum needed in both the X-ray tube and the cathode ray tube?** **6 or 3**
so the electrons do not hit gas particles / electrons are not stopped 6
partial answer (3)

(*vii*) **State one use of a cathode ray oscilloscope.** **3**
one suitable use e.g. (early) TV screens, ECG, checking for voltage/signal etc. 3

**Question 11 56 marks**

Read this passage and answer the questions below

Ernest Rutherford (1871–1937, Nobel Prize 1908) was a brilliant student from New Zealand who, thanks to a grant, moved to the glorious Cavendish Laboratory in Cambridge, full of hopes and ambitions. Later in his life he became a physics professor at the University of Manchester.

One day in 1909, in Manchester, he suggested to his collaborator Hans Geiger and to his student Ernest Marsden that they study the deflection of the so-called alpha-particles. These are positively charged helium ions produced by a radioactive source of radium bromide. This deflection occurs when the alpha-particles pass through a thin film of gold. Experiments of this kind had already been performed, and it had been observed that the alpha-particles are only slightly deflected when they cross the film.

The novelty of Rutherford's suggestion was that he asked his collaborators to check if any alpha-particle bounced back instead of going through the film. Why should a thin metal film reflect heavy high-speed bullets, like the alpha-particles produced by a radioactive source? Geiger and Marsden made their measurement and ran back breathlessly to Rutherford. They had observed that some alpha-particles were indeed bouncing back.

In Rutherford's words: "It was quite the most incredible event that has ever happened to me in my life". He had looked inside the atom and the image he saw was very different from what physicists had expected. A central nucleus, much smaller than the actual size of the atom, holds the entire positive charge and practically all the atomic mass. The rest is just a cloud of light electrons, carrying all the negative charge.

(Adapted from *A Zeptospace Odyssey*, Gian Francesco Giudice, Oxford University Press, 2010)

(*a*) **What are alpha-particles?** **7 or 4**
positively charged helium ions // two protons and two neutrons 7
partial answer e.g. property of alpha particles (4)

(*b*) **Name a source of alpha-particles.** **7 or 4**
radium bromide, uranium, thorium, actinium, radium, etc. 7
partial answer e.g. other named radioactive substance (4)

(*c*) **What material was used as the target in the experiment?** **7 or 4**
gold 7
partial answer e.g. named metal (4)

(*d*) **How did Geiger and Marsden detect the alpha-particles?** **7 or 4**
flashes of light / scintillations 7
partial answer e.g. charge detector (4)

(*e*) **What was the surprising result they observed?** **7 or 4**
some alpha-particles were bouncing back 7
partial answer (4)

(*f*) **What force caused the deflection of the alpha-particles?** **7 or 4**
electric // magnetic 7
partial answer (4)

(*g*) **Outline what the Geiger-Marsden experiment revealed about the structure of the atom.** **7 or 4**
(central) nucleus
much smaller than atom, positive charge, with orbiting electrons etc.
two lines 7
one line (4)

(*h*) **For what invention is Hans Geiger most famous?** **7 or 4**
Geiger-Muller tube /G-M tube /Geiger counter 7
partial answer (4)

**Question 12 56 marks**

**Part (a) A bicycle can be steered by applying a pair of equal but opposite forces to the handlebars, which act as a lever.**

(*i*) **What is meant by the term *lever*?** **2×3**
rigid body 3
free to rotate 3
partial answer e.g. mention of fulcrum (3)

(*ii*) **What is the name given to the turning effect of a force?** **6 or 3**
moment//torque 6
partial answer e.g. reference to perpendicular distance (3)

(*iii*) **What is the name given to a pair of equal but opposite forces?** **6 or 3**
couple 6
partial answer (3)

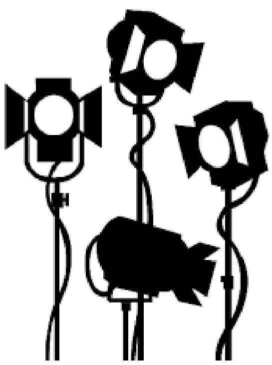
**A cyclist's hands are placed 40 cm apart on the ends of the handlebars. To turn the bicycle, he applies a force of 20 N through each hand. Calculate the turning effect of the force.** **10 or 6 or 4**
$M = 8$ (N m) 10
$M = 0.4 \times 20$ (10-1)
one quantity correctly substituted into equation (6)
any valid equation e.g. $M = Fd$ (4)

**Part (*b*) What is meant by dispersion of light?** **6 or 3**
separation of light into different colours/frequencies/wavelengths 6
partial answer (3)

**What does dispersion of light indicate about the nature of white light?** **6 or 3**
it is made of different colours/frequencies/wavelengths // spectrum 6
partial answer e.g. wave nature (3)

**Name two laboratory techniques that can be used to cause dispersion of light.** **2× 3**
refraction / using a (transparent/glass/perspex) prism 3
diffraction / using a (diffraction) grating/CD disc 3

**Describe one example of dispersion of light occurring in nature.** **4**
rainbow, diamond reflection, reflection off of oil film, etc. 4



**The diagram shows stage lighting similar to that found in most theatres. Only red, green and blue lights are needed to create all the colours needed on stage. Explain why this is so.** **6 or 3**
all other coloured lights can be made from combinations of these lights // these are the three primary colours 6
partial answer (3)

diagram may merit full marks

**Part (*c*) Define resistance. What is the unit of resistance?** **6+3**

$R = \frac{V}{I}$ (when temperature is constant) 6

any relevant equation e.g. $R = VI$ (3)

ohms / Ω 3

**Describe an experiment to demonstrate the heating effect of an electric current.** **3×3**

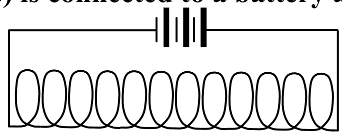
*apparatus*: battery, resistance wire // toaster /(electric) heater/ hairdryer 3
*procedure*: complete the circuit / close the switch 3
*observation/conclusion*: (wire) gets hot 3

**Electrical conduction in different materials is due to the movement of charge carriers. State the charge carriers that are responsible for conduction in each of the following.** **6+2+1+1**

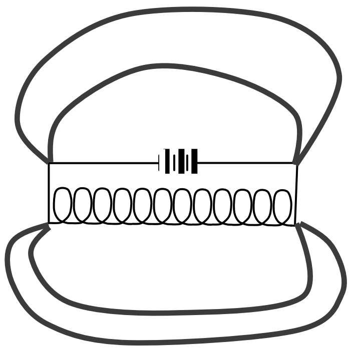
(*i*) **gases**
ions
(*ii*) **semiconductors**
electrons and holes
(*iii*) **metals**
electrons
(*iv*) **solutions**
ions 6+2+1+1

first one correct 6 marks, second one 2 marks, third and fourth correct 1 mark each

**Part (*d*) A solenoid (long coil of wire) is connected to a battery as shown.**



(*i*) **Copy the diagram into your answer book and draw the magnetic field in and around the solenoid.** **6 or 3**
correct shape of field 6
partial answer (3)



(*ii*) **Explain the term *electromagnetic induction*.** **6 or 3**
voltage/emf/current induced due to changing magnetic flux/field 6
partial answer e.g. voltage created (3)

**A magnet and a solenoid can together be used to produce electricity. Describe, with the aid of a diagram, how this can be done.** **4×4**

*apparatus*: magnet, (galvano)meter, solenoid any two 2×4
*procedure:* magnet moves relative to solenoid 4
*observation/conclusion*:the (galvano)meter/needle deflects /emf / voltage / electricity produced 4

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