Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2020

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.

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

3. 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.

4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

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

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

SECTION A (120 MARKS)

Answer **three** questions from this section. Each question carries 40 marks.

Question 1. 40 marks

A student performed an experiment to investigate the principle of conservation of momentum. He released one trolley and it travelled along a track and collided with a second trolley at rest. After the collision, the trolleys stick together (their masses are combined) and they travel along the track. Before setting up the experiment, the student measured the mass of each trolley.

Mass of trolley A = 0.38 kg Mass of trolley B = 0.35 kg

Draw a labelled diagram of the apparatus used in this experiment. **3 × 3**

runway //air track 3

two trolleys // two gliders/riders 3

detail e.g. timer, sticking mechanism 3

NOTE: no labels deduct 2

accept valid alternatives e.g. data logging methods

(*ii*) How did the student measure the masses of the trolleys? **3**

used electronic balance / mass balance / weighing scales / weigh them 3

To calculate the velocity of the trolleys, the student measured distance and time.

(*iii*) Describe how the distance was measured. **3**

metre stick/ measuring tape 3

(*iv*) Describe how the time was measured. **3 + 3**

tickertape / timer // photogates / timer 3

time between dots is 0.02 s // difference between entry/exit times 3

(*v*) How did the student use the distance and the time to calculate the velocity? **6 or 3**

$v = \frac{s}{t}$ // slope of distance versus time graph 6

partial answer (3)

Starting velocity of trolley A =1.5 m s^{-1}. Starting velocity of trolley B = 0 m s^{-1}.
Final velocity of trolleys A and B together = 0.78 m s^{-1}.

The principle of conservation of momentum states that the momentum before the collision is equal to the momentum after the collision.

The momentum of trolley A before the collision = 0.38 × 1.5 = 0.57 kg m s^{-1}.

(*vi*) What is the momentum of trolley B before the collision? **3**

0 kg m s^{-1} 3

(*vii*) Calculate the combined momentum of trolleys A and B after the collision. (Show your work.) **6 or 3**

(0.38 + 0.35)(0.78) = 0.569 kg m s^{-1} 6

partial answer (3)

(*viii*) Was momentum conserved in this collision? Explain your answer. **2 + 2**

yes 2

momentum before was the same as momentum after 2

Question 2 40 marks

A student carried out an experiment to measure the focal length of a concave mirror.

(*i*) Draw a labelled diagram of the apparatus used in this experiment. **4 × 3**

labelled diagram to show:

concave mirror
object e.g. crosswire
image / screen
correct arrangement
detail e.g. optical bench, metre stick, ray-box, etc.

any 4 lines correct 4 × 3

approximate method maximum mark 3×3
NOTE: no labels, deduct 2
accept valid alternatives

(*ii*) State the formula used to calculate the focal length. **6 or 3**

$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ 6

partial answer (3)

(*iii*) On your diagram, indicate and label the measurements taken by the student. **6 or 3**

correctly marked *u* and *v* distances 6

partial answer (3)

(*iv*) What instrument was used to take these measurements? **6**

metre stick/ measuring tape // optical bench scale 6

(*v*) Why did the student measure the approximate focal length at the start of the experiment? **6 or 3**

to ensure the object is placed outside the focal point // for a real image 6

partial answer (3)

(*vi*) The image distance is the less accurate measurement. Explain why. **4**

difficult to decide location of sharpest image 4

Question 3 **40 marks**

A student carried out an experiment to investigate how the fundamental frequency of a stretched string changes with length.

(*i*) Draw a labelled diagram of the apparatus used in this experiment. **4 × 3**

labelled diagram to show:

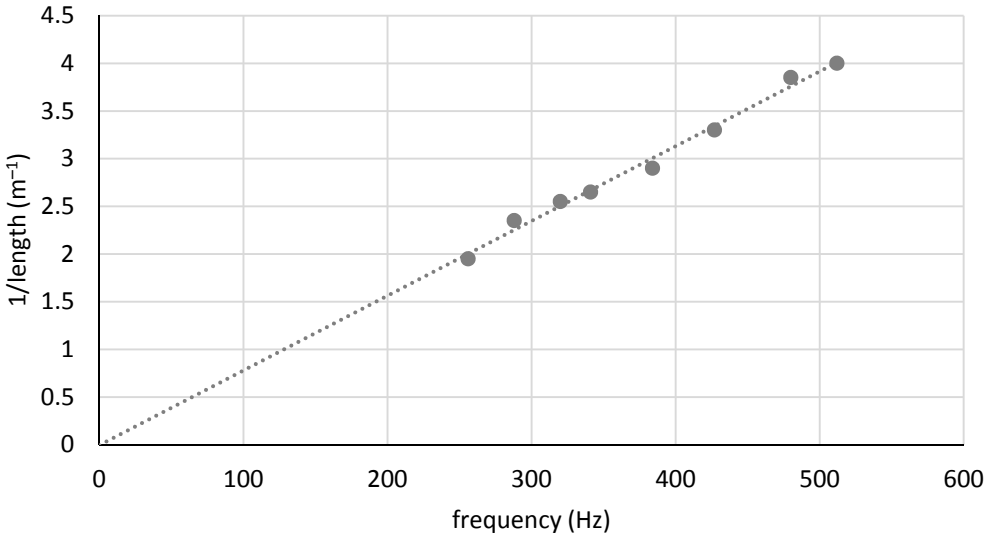
string
means of changing frequency e.g. tuning forks / frequency generator
means of varying length e.g. bridge
means of measuring length
means of detecting resonance /paper rider /magnet
detail e.g. sonometer, means of tightening any four lines 4×3

NOTE: no labels, deduct 2, incorrect experiment maximum mark 3× 3
accept valid alternatives

(*ii*) On your diagram, indicate and label the length measured by the student. **4**

distance between the bridges shown on the diagram 4

The student completed the following graph to show the relationship between length and frequency.



(*iii*) How did the student measure the frequency values? **6 or 3**

noted it from tuning forks // read it from signal generator 6
partial answer (3)

(*iv*) How did the student set the string vibrating? **6 or 3**

placed a vibrating tuning fork on bridge // varied the frequency of the signal generator 6
partial answer (3)

(*v*) The length between the bridges is adjusted until resonance occurs. Describe how the student knew that resonance had occurred. **6 or 3**

paper rider falls off // loudest sound 6
partial answer (3)

(*vi*) State the relationship between the resonance frequency and the length. **6 or 3**

$f \propto \frac{1}{l}$ / frequency is inversely proportional to the length // fl = constant 6
partial answer (3)

Question 4 **40 marks**

A student performed an experiment to investigate how the resistance of a metallic conductor changes with temperature.

(*i*) **Name the instrument used to measure resistance.** **6 or 3**
ohmmeter 6
partial e.g. multimeter (3)

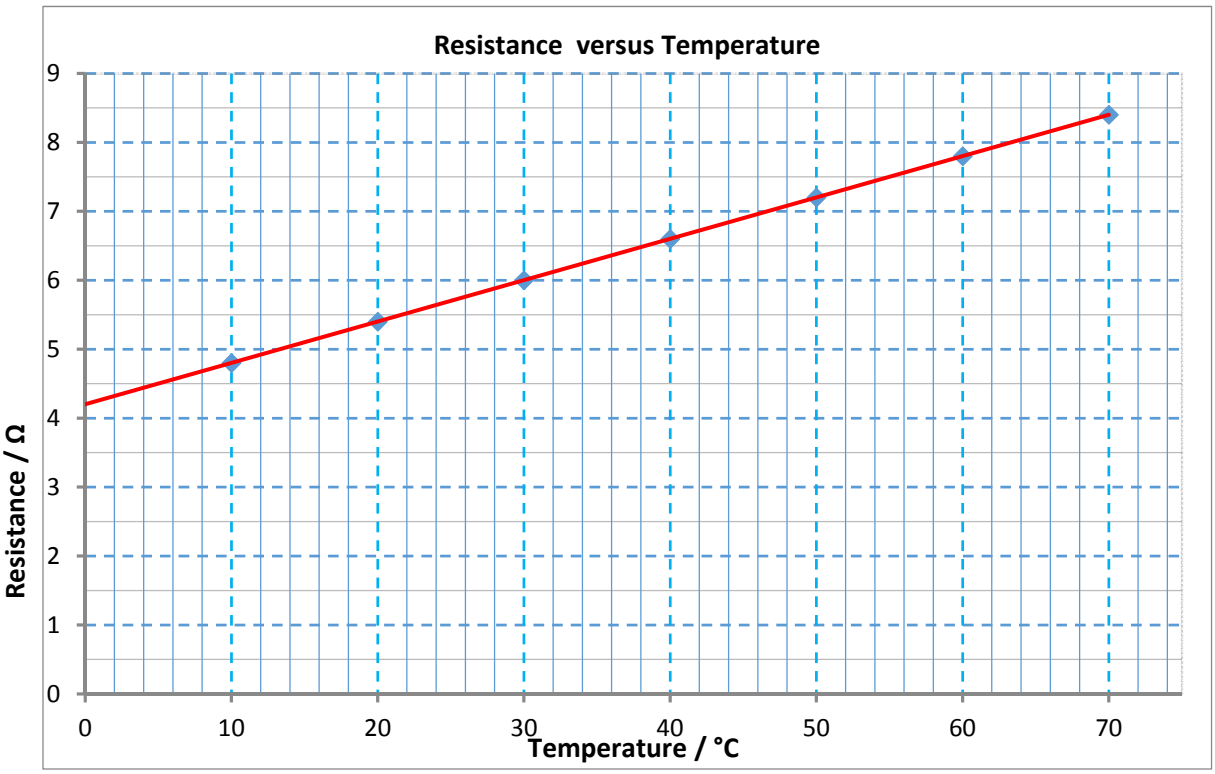
(*ii*) **Name the instrument used to measure temperature.** **6**
thermometer / temperature probe 6

(*iii*) **How did the student change the temperature of the metallic conductor?** **2 × 3**
placed in liquid 3
source of heat 3

The student recorded the following data:

Temperature (°C)	**10**	**20**	**30**	**40**	**50**	**60**	**70**
Resistance (Ω)	**4.8**	**5.4**	**6.0**	**6.6**	**7.2**	**7.8**	**8.4**

(*iv*) **Use the data to plot a graph to show the relationship between resistance and temperature.** **3 + 6 + 3**
label axes correctly, (name / symbol / unit acceptable) 3
plot six points correctly 6
-1 for each error thereafter
straight line 3
if graph paper is not used, maximum mark 3 × 3



(*v*) **Describe the relationship between resistance and temperature.** **6 or 3**
resistance increases with temperature // linear 6
partial answer (3)

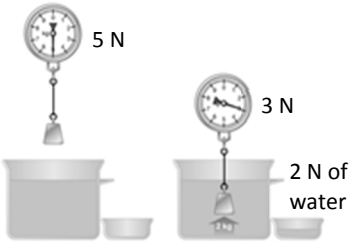
(*vi*) **State one safety precaution that the student should have taken.** **4 or 2**
use a tongs / avoid being burnt, etc. 4
partial answer (2)

SECTION B (280 MARKS) Answer five questions from this section. Each question carries 56 marks.

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

Answer any eight of the following parts (*a*), (*b*), (*c*), etc.

(*a*) Explain Archimedes' principle.
The diagram may help you answer.



7 or 4

upthrust (apparent loss in weight) = weight of displaced fluid — two lines 7; one line (4)

(*b*) What is meant by latent heat? **7 or 4**

heat/energy needed to change state — 7

partial answer — (4)

(*c*) Which of the following is the SI unit of capacitance? **7**

ampere coulomb **farad** volt — 7

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

pressure and volume are inversely proportional // PV = k // $P \propto \frac{1}{V}$ — 7

partial answer — (4)

(*e*) An electric heater has a power rating of 1500 W. It uses a voltage of 230 V. Which fuse should be used in the plug, a 3 A fuse or a 13 A fuse? Justify your answer.

7 or 4

13 A

$\frac{1500}{230}$ / 6.5 A / $I = \frac{P}{V}$ / $P = VI$ / current too big ./ fuse would blow — two lines 7; one line (4)

(*f*) What is a magnetic field? **7 or 4**

region/space
where magnetic forces can be experienced — two lines 7; one line (4)

(*g*) Ultraviolet light is on the electromagnetic spectrum. State two properties of ultraviolet light. **7 or 4**

travels at *c*, high energy/frequency, causes ionisation, etc. — any two **7**; any one (4)

(*h*) A pair of complementary colours consists of a primary colour and a secondary colour that mix to give white light. Name a pair of complementary colours. **7 or 4**

blue and yellow // red and turquoise/cyan // green and magenta — 7

partial answer — (4)

(*i*) Name the piece of equipment on the right. **7 or 4**

spectrometer — 7

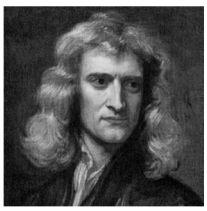
partial answer e.g. collimator, turntable, telescope — (4)

(*j*) What is nuclear fusion? **7 or 4**

joining of two nuclei with the release of energy — 7

partial answer — (4)

Question 6 **56 marks**



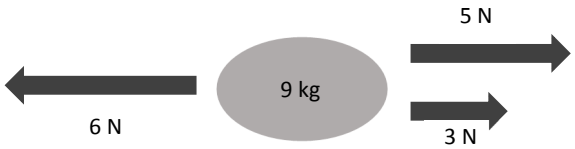
Sir Isaac Newton was an English mathematician and physicist. He is widely recognised as one of the most influential scientists of all time.
Newton's first law of motion states that a body remains at rest or moving at a constant velocity unless an unbalanced external force acts on it.

(*i*) **A block weighs 400 N. A crane lifts the block so that it moves upwards with constant velocity. Use Newton's first law of motion to find the force that the crane puts on the block.** **6 or 3**

(crane force up = weight of block down =)400 N 6

partial answer e.g. zero acceleration (3)

Newton's second law of motion states that the force on an object is proportional to its rate of change of momentum.



(*ii*) **Calculate the resultant (net) force on the 9 kg object in the diagram above. In what direction does it act?** **6 or 3**

2 N to the right 6

partial answer (3)

(*iii*) **Calculate the acceleration of the 9 kg object.** **9 or 6 or 3**

($a = \frac{F}{m} = \frac{2}{9}$ =) 0.22 m s^{-2} 9

one error (6)

partial answer (3)

(*iv*) **State Newton's third law of motion.** **6 or 3**

to every action there is an equal but opposite reaction 6

partial answer (3)

(*v*) **Use Newton's third law to explain how a rocket takes off. (A labelled diagram may help your answer.)** **3**

when the rocket forces gas down, the gas applies a force up on the rocket (3)

A car of mass 700 kg is at rest. It accelerates at a constant rate for 6 seconds until it is travelling at a velocity of 18 m s^{-1}.

(*vi*) **Calculate the kinetic energy of the car when it is travelling at 18 m s^{-1}.** **6 or 3**

($E = \frac{1}{2}mv^2 = \frac{1}{2}(700)(18)^2$ =) 113400 J 6

partial answer (3)

(*vii*) **Calculate the acceleration of the car.** **6 or 3**

($a = \frac{v-u}{t} = \frac{18-0}{6}$ =) 3 m s^{-2} 6

partial answer (3)

(*viii*) **Calculate the net force on the car as it accelerates.** **6 or 3**

($F = ma$ = (700)(3)=) 2100 N 6

partial answer (3)

The engine of the car provides a driving force of 3000 N.

(*ix*) **Calculate the friction acting on the car.** **4**

(3000 – 2100 =)900 N 4

(*x*) **State one method of reducing friction.** **4**

oil moving parts // smooth road surface, etc. 4

Question 7 **56 marks**

Light undergoes refraction as shown in the picture.
Refraction is the bending of light as it passes from one medium into another.

(*i*) **State Snell's law of refraction.** **6 or 3**

sine of the angle of incidence is proportional to sine of the angle of refraction // $\frac{\sin i}{\sin r} = \text{constant}$ // sin i ∝ sin r 6

partial answer (3)

(*ii*) **Describe an experiment to demonstrate Snell's law.** **4 × 3**

apparatus: glass/plastic block 3

ray box / laser / optical pins / protractor 3

procedure: draw refracted rays and measure values for *i* and *r* 3

observation /conclusion: Sin *i* ∝ sin *r* 3

(*iii*) **A beam of light travelling from air strikes the surface of water. The angle of incidence is 36° and the angle of refraction is 26°. Use Snell's law to calculate the refractive index of water.** **6 or 3**

($n = \frac{\sin 36}{\sin 26} = \frac{0.588}{0.438}$ =) 1.34 6

partial answer (3)

Refractive index can also be calculated using the formula $n = \frac{1}{\sin C}$.

(*iv*) **What does *C* stand for in the formula written above?** **6 or 3**

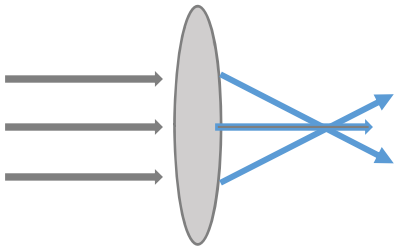
critical angle 6

partial answer (3)

A converging lens refracts light.

(*v*) **Copy and complete the diagram below to show the paths of the rays of light after they strike the converging lens.** **6 or 3**

correct diagram 6



partial answer (3)

A converging lens can be used to produce a magnified <u>virtual</u> image.

(*vi*) **Explain the underlined term.** **4**

one formed by the apparent intersection of rays // image not formed on screen 4

A converging lens has focal length 15 cm (*f* = 15cm). An object is placed 20 cm in front of the lens (*u* = 20 cm).

(*vii*) **Calculate the image distance, *v*.** **6 or 3**

($\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} - \frac{1}{20} = \frac{1}{60}$) *v* = 60 cm 6

partial answer (3)

(*viii*) **Calculate the magnification, *m*.** **6 or 3**

($m = \frac{v}{u} = \frac{60}{20}$ =) 3 6

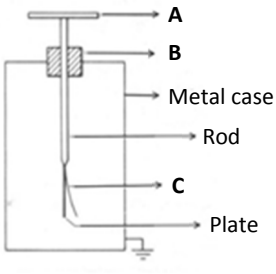
partial answer (3)

(*ix*) **State one use of a lens.** **4**

magnifying glass, eye glasses /spectacles, camera, telescope etc. any one 4

Question 8 **56 marks**

A gold leaf electroscope is used to perform experiments involving static electricity.



(*i*) **Name the parts of the gold leaf electroscope labelled A, B and C.** **3 × 3**

A = (metal) cap / disc 3

B = insulation 3

C = (gold) leaf 3

When two different materials are rubbed together, they become electrically charged.

(*ii*) **Describe how a student would charge a plastic rod.** **6 or 3**

rub with a (dry) cloth / fur 6

partial answer (3)

(*iii*) **How would the student use a gold leaf electroscope to show that the rod is charged?** **2 × 3**

bring the charged rod close to the cap // touch the cap with the charged rod 3

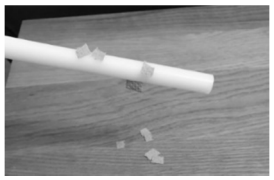
leaf moves 3

partial answer (3)

(*iv*) **State the SI unit of electric charge.** **3**

coulomb (3)

(*v*) **The photograph above shows a charged plastic rod attracting small pieces of paper to it. Explain how this happens.** **2(6 or 3)**



charged rod induces opposite charge on the paper 6

partial answer (3)

opposite charges attract 6

partial answer (3)

(*vi*) **Describe, with the aid of a labelled diagram, an experiment to show an electric field pattern. On your diagram, show the electric field, including its direction.** **5 × 3**

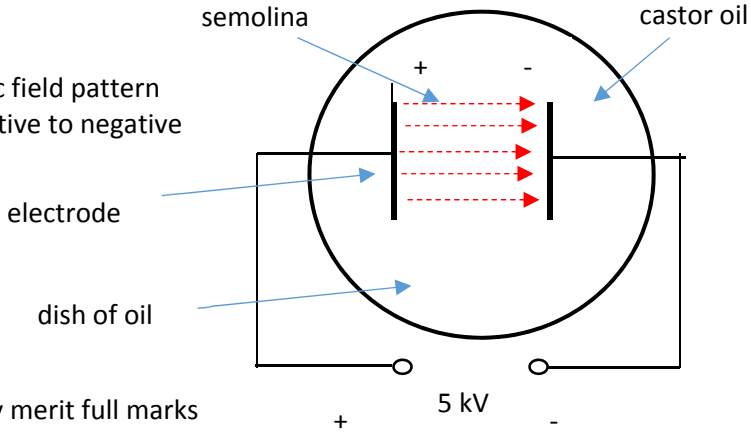
dish of (castor) oil 3

high voltage source 3

two electrodes/plates 3

semolina forms electric field pattern 3

field lines go from positive to negative 3



a labelled diagram may merit full marks

(*vii*) **Coulomb's law describes the force between static charges. It is an example of an inverse square law. State another example of an inverse square law.** **5 or 3**

Newton's law of universal gravitation // $F \propto \frac{Mm}{d^2}$ 5

partial answer (3)

Question 9 56 marks

Light travels as a wave of electromagnetic radiation. The colour of the light depends on its frequency.

(*i*) Light is an example of a transverse wave. Explain what is meant by a transverse wave. (A labelled diagram may help your answer.) **6 or 3**

disturbance is perpendicular to direction of propagation of the wave 6

partial answer (3)

(*ii*) Orange light has a frequency of 5×10^{14} Hz. The speed of light is 3×10^8 m s^{-1}. Calculate the wavelength of the orange light. **6 or 3**

($\lambda = \frac{c}{f} = \frac{3 \times 10^8}{5 \times 10^{14}}$ =) 6×10^{-7} m 6

partial answer (3)

Sound also travels as a wave. Sound is an example of a mechanical wave.

(*iii*) Describe an experiment to show that sound needs a medium to travel through. **4 × 3**

apparatus: bell jar with electric bell, battery, vacuum pump any two 2×3

procedure: turn on pump 3

observation/conclusion: no sound heard when air removed / sound needs a medium 3

accept valid alternatives

a labelled diagram may merit full marks

Sound waves undergo reflection, refraction, diffraction and interference.

(*iv*) What is meant by reflection? **6 or 3**

waves rebounding /bouncing off a surface 6

partial answer (3)

(*v*) Describe an experiment to show the interference of sound waves. **3 × 3**

apparatus: tuning fork 3

procedure: strike the tuning fork and rotate it close to your ear 3

observation/ conclusion: the emitted sound increases and decreases in loudness due to interference 3

accept valid alternatives

(*vi*) Sound waves do not undergo polarisation. Explain why. **3**

longitudinal // not transverse 3

As an ambulance passes a stationary observer, its siren emits a sound of a particular frequency. This frequency appears to change as the ambulance passes the observer. This is caused by the Doppler effect.

(*vii*) Describe a laboratory experiment to demonstrate the Doppler effect. **3 × 3**

apparatus: buzzer/sound source 3

procedure: turn on sound source and rotate using string 3

observation/conclusion: frequency /pitch changes (as sound source moves closer/away) 3

(*viii*) State one use of the Doppler effect. **5 or 3**

measuring speed / speed gun, (measuring) red shift, ultrasonic scanners, imaging used to study blood flow, used to study heartbeat, weather forecasting, etc. any one 5

partial answer e.g. general use such as medicine, radar, sonar (3)

Question 10 56 marks

Irish physicist G.J. Stoney named the electron in 1891. J.J. Thomson identified it as a particle in 1897.

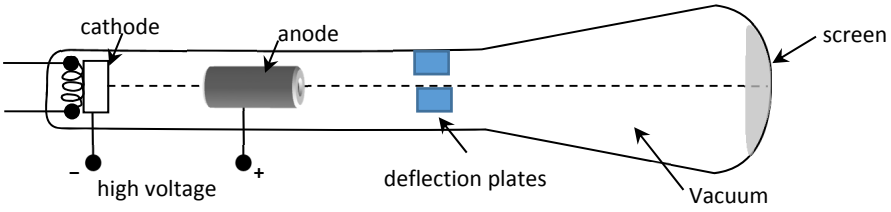
(*i*) Where in the atom is the electron found? **3**
(obits) outside the nucleus 3

(*ii*) Compare the mass of an electron to the mass of a proton. **3**
electron has smaller mass // 9.1×10^{-31} versus 1.67×10^{-27} 3

Electrons are produced in a cathode ray tube by thermionic emission.

(*iii*) What is meant by thermionic emission? **6 or 3**
release of electrons from the surface of a hot metal 6
partial answer (3)

(*iv*) Draw a labelled diagram of a cathode ray tube. **4 × 3**
(heated)cathode, anode, high voltage, vacuum, deflection plates any four 4 × 3



(*v*) How are the electrons detected in a cathode ray tube? **3**
flashes of light / scintillations (on fluorescent screen) 3

(*vi*) State one use of a cathode ray tube. **3**
CRO, old TV monitors, ECG screens, etc. 3

The photoelectric effect is the emission of electrons from the surface of a metal when light of a suitable frequency falls on it.

(*vii*) Describe an experiment to demonstrate the photoelectric effect. **4 × 3**
apparatus: (gold leaf) electroscope 3
UV lamp 3
procedure: place a zinc plate on the cap of the electroscope / charge the electroscope negatively / shine the UV lamp on the zinc plate 3
observation /*conclusion*: the leaf collapses /electrons emitted 3
marks may be obtained from a diagram
accept valid alternatives

The picture shows an X-ray tube.

(*viii*) What is an X-ray? **6 or 3**
high energy/frequency electromagnetic radiation 6
partial answer (3)

(*ix*) Explain why the production of X-rays can be considered to be the opposite of the photoelectric effect. **4 or 2**
fast electrons produce X-radiation while high frequency radiation produces electrons 4
partial answer (2)

(*x*) State one danger associated with X-rays. **4 or 2**
can cause skin burns, cancer, ionise cells, death, etc. any one 4
partial answer (2)

Q11 56 marks

Read the following passage and answer the questions below.

WHAT ARE GREENHOUSE GASES?

A wide range of gases contribute to climate change. These are known as greenhouse gases. The most important greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases contribute to the greenhouse effect by absorbing infrared radiation.

The impact of greenhouse gas emissions on climate disruption must be addressed. Ireland has experienced the extreme weather events of flooding, drought, and heavy snow. However, many countries have experienced much worse. Climate change is bringing about desertification, rising sea levels, displaced populations, and severe challenges to the natural world. These have contributed to significant economic and social disruption. We are close to a tipping point where these crises will get much worse.

Decarbonisation is now a must if the world is to contain the damage and build resilience in the face of this challenge. Agenda 2030 and the Paris Agreement on climate change require a transformational shift in our economies and societies towards sustainable development. Ireland and the international community are responding to this requirement, setting out a profound change in the practices which support our lifestyle. Every home, community, and workplace must be mobilised to get involved.

Ireland's climate change plan contains important measures to make Ireland's development more climate friendly, including achieving the following by 2030:

- A target of 55% renewable power, i.e. from a source that does not get depleted.
- Retrofit plans for 450,000 homes with insulation to a Building Energy Rating (BER) of B2.
- At least half a million electric vehicles on the road, with additional charging infrastructure.

Adapted from dccae.gov.ie

(*a*) Name two greenhouse gases that are contributing to climate change. **7 or 4**

carbon dioxide/CO_2, methane / CH_4, nitrous oxide/N_2O	any two	7
	any one	(4)

(*b*) State one of the impacts of climate change that Ireland has experienced. **7**

flooding, drought, heavy snow	any one	7

(*c*) An electric car uses a battery to make the car move. What energy conversion takes place when this happens? **7 or 4**

chemical to kinetic // chemical to electric // electric to kinetic	any one	7
partial answer		(4)

(*d*) What is renewable power? **7**

power from a source that does not get depleted	7

(*e*) What is the SI unit of power? **7**

watt	7

(*f*) The BER rating of a home is dependent on the *U*-value of the materials used. What is meant by *U*-value? **7 or 4**

energy passing through a material per m^2 per K per s	7
partial answer	(4)

(*g*) Wind energy is a significant source of renewable power in Ireland. A wind turbine generates 90 MJ of energy in 60 seconds. Calculate the power of the turbine. **7 or 4**

$(P = \frac{E}{t} = \frac{9\times10^6}{60} =)$ 1.5×10^6 W	7
partial answer	(4)

(*h*) Other than wind energy, name two other sources of renewable power used in Irish homes. **7 or 4**

solar, wave, tidal, hydro, geothermal, biomass	any two	7
	any one	(4)

Question 12 56 marks

Answer any two of the following parts (*a*), (*b*), (*c*), (*d*).

Part(*a*) A bus travels 30 km in 28 minutes at a constant speed.

(*i*) Convert 30 km into metres. **6**

30000 m 6

(*ii*) Convert 28 minutes into seconds. **3**

(28 × 60 =) 1680 s 3

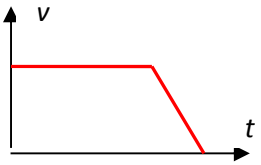
(*iii*) Use your answers to (*i*) and (*ii*) to calculate the speed of the bus in m s^{-1}. **6 or 3**

$(v = \frac{s}{t} = \frac{30\,000}{1680} =)$ 17.86 m s^{-1} 6

partial answer (3)

The driver applies the brakes and brings the bus to a stop in 30 seconds.

(*iv*) Sketch a velocity-time graph of the bus's journey. **3 × 3**



labelled axes 3

constant speed (horizontal line) for most of the journey 3

sharp deceleration to zero shown 3

(*v*) What is the difference between speed and velocity? **4**

velocity is the speed in a given direction (4)

Part (*b*) A thermometer is used to measure temperature.

(*i*) What is meant by temperature? **6 or 3**

degree of hotness // measure of how hot or cold a body is 6

partial answer e.g. the heat in a body (3)

(*ii*) Body temperature is 37 °C. Convert this to kelvin (K). **3**

(37 + 273 =) 310 K 3

A thermometer is based on a particular thermometric property.

(*iii*) What is a thermometric property? **6 or 3**

one that changes measurably with (changing) temperature 6

partial answer (3)

(*iv*) Name one example of a thermometric property. **4**

colour, resistance, pressure, volume, emf, voltage, etc. any one **4**

An uncalibrated thermometer is one that has no markings or numbers on it.

(*v*) Describe an experiment to calibrate a thermometer. **3 × 3**

apparatus: beaker of water, heat source, calibrated and uncalibrated thermometers 3

procedure: measure thermometric property at different reference temperatures 3

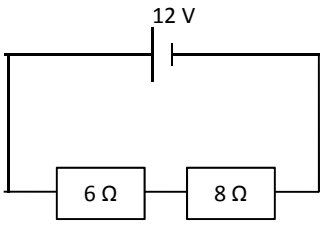
observation/conclusion: draw a scale/ graph 3

Part (*c*) An electric current is a flow of electric charge. A material that allows electric charge to flow through it is called an electrical conductor.

(*i*) Name a material that is an electrical conductor. **3**
metal 3

(*ii*) What is the name given to a material that does not allow electric charge to flow through it? **3**
insulator 3

(*iii*) Describe an experiment to show that a material is an electrical conductor. **3 × 3**
apparatus: circuit to show power source, ammeter/ bulb, leads, contacts 3
procedure: connect the circuit and place item between contacts 3
observation/conclusion: bulb lights / item conductor 3



(*iv*) Calculate the total resistance in the circuit shown above. **6**
(6 + 8 =) 14 Ω 6

(*v*) Calculate the current flowing in the circuit. **7 or 4**
($I = \frac{V}{R} = \frac{12}{14}$ =) 0.86 A 7
partial answer (4)

Part (*d*) When the nuclei in certain atoms undergo radioactive decay, they emit one or more types of radiation – alpha, beta and gamma.

(*i*) Which type of radiation is the most penetrating? **3**
gamma 3

(*ii*) Describe an experiment to compare the penetrating power of alpha, beta and gamma radiation. **4 × 3**
apparatus: radioactive sources, barriers, detector/GM tube any two 2 × 3
procedure: place different barriers between the sources and the detector 3
observation/conclusion: alpha is stopped first // gamma penetrates best 3

The nuclear equation below shows the alpha decay of an isotope of radon.

$$\mathbf{Rn_{86}^{220} \rightarrow X_A^Z + \alpha_2^4}$$

(*iii*) Calculate the atomic number, *A*, of the unknown element *X*. **3**
84 3

(*iv*) Calculate the mass number, *Z*. **3**
216 3

(*v*) Name element *X*. **3**
Polonium / Po 3

(*vi*) State one use of nuclear radiation. **4 or 2**
sterilise food, sterilise medical equipment, cancer therapy, energy source, etc. any one 4
partial answer (2)