Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2016

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**

A student carried out an experiment to verify the principle of conservation of momentum. During the experiment, the student took measurements to find mass and velocity.

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

labelled diagram to show:
2 trolleys / 2 riders
runway / air-track
timer e.g. photo-gates (and timer) / tickertape (and timer)
means of trolleys joining
detail e.g. sloped runway, means of measuring mass / time / distance,

one line (3) two lines (2 × 3) three lines (3 × 3) four lines 4 × 3

NOTE: no labels, deduct 2
incorrect arrangement, deduct 2
accept valid alternatives e.g. data logging methods

(*ii*) How was mass measured? **6 or 3**

used (electronic) balance / used weighing scales / weighed them 6
partial answer e.g. mentions spiral spring (3)

(*iii*) What measurements were taken to calculate velocity?
How were these measurements used to calculate velocity? **3 × 3**

(relevant) distance specified 3
(relevant) time specified 3
$(\text{velocity}=)\frac{\text{distance}}{\text{time}}$ / $\frac{s}{t}$ 3
partial answer e.g. measure time / measure distance / detail (3)
reference to a datalogger would merit at least 3

(*iv*) How did the student determine the momentum? **6 or 3**

mv 6
partial answer e.g. using the equation / m / v (3)

(*v*) How did the student verify the principle of conservation of momentum? **7 or 4**

momentum before = momentum after / $m_1u = (m_1 + m_2)v$ /
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ 7
partial answer (4)

Question 2 **40**

An experiment was set up to determine the refractive index of a material.

(*i*) Draw a labelled diagram of the arrangement of the apparatus used in this experiment. **6 + 2 × 3**

labelled diagram to show:

glass/plastic block	// container of liquid	6
ray box / laser / optical pins	// optical pins	3
detail e.g. protractor	// metre stick / mirror	3

other valid methods acceptable

incorrect experiment, maximum mark 6 + 3

NOTE: no labels, deduct 2
incorrect arrangement, deduct 2
accept valid alternatives

(*ii*) Indicate on your diagram the measurements that were taken. **6 + 3**

angle of incidence / *i* // real depth
angle of refraction / *r* // apparent depth

two lines 6 + 3
one line (6)

critical angle (6 + 3)

partial answer e.g. angles / height (3)

(*iii*) What instrument was used to take these measurements? **6 or 3**

protractor // metre stick / ruler 6

partial answer e.g. describes how to measure (3)

(*iv*) How was the refractive index calculated? **7 or 4**

$(n =)\frac{\sin i}{\sin r}$ // $(n =)\frac{\text{real depth}}{\text{apparent depth}}$ // $(n =)\frac{1}{\sin c}$ 7

partial answer e.g. one error, $n = \sin i \times \sin r$ / $n = \frac{c_1}{c_2}$ (4)

(*v*) Why should the experiment be repeated? **6 or 3**

for increased accuracy / to get average / to draw a graph 6

partial answer (3)

Question 3 **40**

A student carried out a laboratory experiment to find the speed of sound in air.

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

labelled diagram to show:
(resonance) tube 3
tuning fork / signal generator 3
means of measuring length e.g. ruler / metre stick / means of changing length 3
detail e.g. fork over the mouth of tube 3
partial answer (3)

NOTE: no labels, deduct 2
incorrect arrangement, deduct 2
accept valid alternatives e.g. data logging methods

(*ii*) How did the student find the frequency of the sound wave used? **6 or 3**

(read it) from the tuning fork / signal generator // used tuning forks of known frequency 6
partial answer (3)

(*iii*) What other measurements did the student take? **6 + 3**

measure length of vibrating air
measure diameter of tube // measure length for next resonance
detail e.g. equation $\lambda = 4(l + 0.3d)$ // $\lambda = 2(l_2 - l_1)$ // end-correction
two lines 6 + 3
one line (6)
partial answer e.g. using a ruler (3)
marks may be obtained from a diagram

(*iv*) How did the student calculate the speed of sound in air? **3 × 3**

$c = 4f(l+0.3d)$ / $c = f\lambda$ 3 × 3
one error (2 × 3)
partial answer e.g. $\lambda = 2(l_2 - l_1)$ / substituted measurements into the formula (3)

(*v*) State one precaution which the student might have taken to get an accurate result. **4 or 2**

use a vernier callipers to find the diameter of the tube, quiet background,
use a tuning fork of high frequency as it is easier to hear, avoid no parallax,
get the second resonance position to eliminate the end-correction, etc. 4
partial answer e.g. use more sensitive instruments, repeat the experiment to get a more accurate result (2)

Question 4 **40**

In an experiment to verify Joule's law, a heating coil was placed in a fixed mass of water. A current *I* was allowed to flow through the coil for a fixed length of time and the rise in temperature, $\Delta\theta$, was recorded. This was repeated for different values of *I*. The table below shows the data recorded.

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

ammeter / multimeter, heating coil, calorimeter any one (3) all three 2 × 3
(variable) power supply 3
detail e.g. closed circuit, stop watch, insulation, variable resistance, thermometer 3
NOTE: no labels, deduct 2
incorrect arrangement, deduct 2
accept valid alternatives methods

(*ii*) How was the current changed during the experiment? **4**

adjust the (variable) power supply / (variable) resistor 4

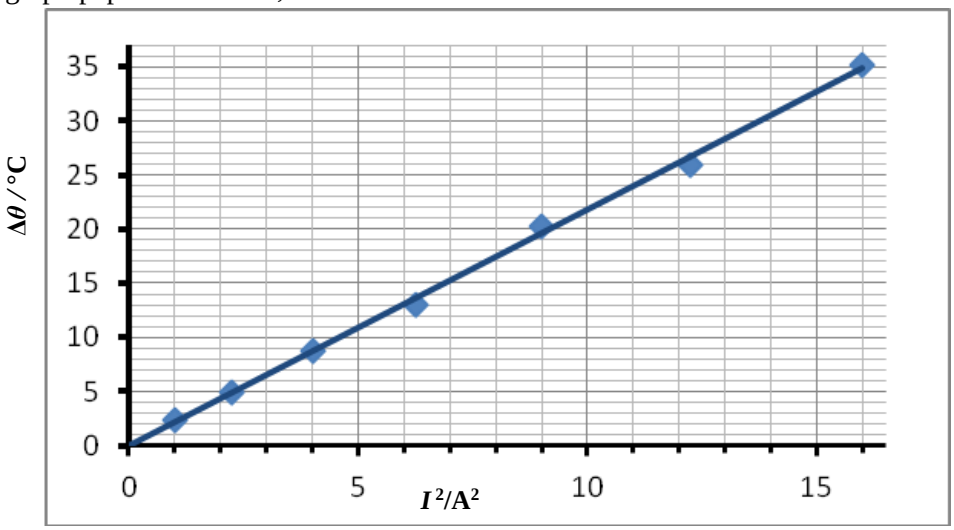
(*iii*) Copy the table below and complete it in your answerbook. **6 × 1**

I (A)	1.0	1.5	2.0	2.5	3.0	3.5	4.0
I^2 (A^2)	**1**	2.25	**4**	**6.25**	**9**	**12.25**	**16**
$\Delta\theta$ (°C)	2.3	4.9	8.8	13.0	20.2	26.0	35.2

all correct 6 × 1

(*iv*) Using the data in the completed table, draw a graph on graph paper of $\Delta\theta$ against I^2. **4 × 3**

label axes correctly (name / symbol / unit acceptable) 3
plot three points correctly 3
plot another three points correctly 3
straight line 3
if graph paper is not used, maximum mark 3 × 3



(*v*) Explain how your graph verifies Joule's law. **6 or 3**

(straight) line through origin // $\Delta\theta \propto I^2$ / $P \propto I^2$ 6
partial e.g. $\propto$ **(**3)
answers must be consistent with graph drawn

Section B **(280 marks)**

Three questions to be answered.

Question 5 **56**

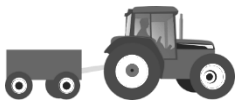
Answer any eight of the following parts, (*a*), (*b*), (*c*), etc.

(*a*) **State the principle of Archimedes.** **7 or 4**

(when a body is immersed in a liquid) the upthrust is equal to the weight of the displaced liquid 7

partial answer e.g. upthrust (4)

(*b*) **A tractor applies a force of 500 N to pull a trailer a distance of 3 km. Calculate the work done by the tractor.** **7 or 4**



($W = Fs$ = 500 ×3000 =) 1.5 × 10^6 (J) 7

partial answer (4)

(*c*) **Choose from the list below the instrument used to measure (*i*) pressure, and (*ii*) energy.** **7 or 4**

opisometer **(*i*) barometer** hydrometer **(*ii*) joulemeter** 7

partial answer i.e. one correct (4)

(*d*) **State two uses for a concave mirror.** **7 or 4**

headlights, makeup, shaving mirrors, etc. two correct 7

partial answer e.g. 2 uses of a convex mirror one correct (4)

(*e*) **Conduction is one method of heat transfer. Name the other two methods.** **7 or 4**

convection, radiation 7

partial answer i.e. one correct (4)

(*f*) **What is the function of a lightning conductor?** **7 or 4**

to earth / protect building / safety / point discharge 7

partial answer e.g. metal rod (4)

(*g*) **There are 150 turns in the primary coil of a transformer and 3000 turns in the secondary coil. Calculate the output voltage when 12 V a.c. is connected across the primary coil.** **7 or 4**

$(V_0 =) \dfrac{3000 \times 12}{150}$ // 240 (V) 7

partial answer e.g. correct equation (4)

(*h*) **State one common use of the electroscope.** **7 or 4**

test for charge, identify charge, measure potential etc. 7

partial answer (4)

(*i*) **What is the photoelectric effect?** **7 or 4**

emission of electrons when light (radiation) is incident 7

partial answer e.g. emission of electrons (4)

(*j*) **What are alpha-particles?** **7 or 4**

helium nucleus / He^{++} / two protons and two neutrons 7

partial answer e.g. helium, protons and neutrons, (nuclear) radiation (4)

Question 6 **56**

Define the term force and state the unit of force. **6 + 3**

force is anything that causes a body to accelerate // $F=ma$ 6

partial e.g. relevant force equation (3)

newton / N 3

Force is a vector quantity. Name another example of a vector quantity. **6 or 3**

displacement, velocity, acceleration, etc. 6

partial answer (3)

The *New Horizons* spacecraft visited the minor planet Pluto in 2015. Newton's law of universal gravitation is used to calculate the force between two bodies, for example Pluto and the *New Horizons* spacecraft.

State the factors which affect the size of the gravitational force between two bodies. **3 × 3**

mass of first body

mass of second body

distance

G any three 3 × 3

masses (2 × 3)

partial answer (3)

Pluto has a mass of 1.3×10^{22} kg and a radius of 1186 km. Use the equation below, which is taken from page 56 of the *Formulae and Tables* booklet, to calculate g, the acceleration due to gravity on the surface of Pluto. **4 × 3**

$(g = \frac{GM}{d^2} = \frac{(6.67\times10^{-11})(1.3\times10^{22})}{(1.186\times10^{6})^2} = \frac{8.67\times10^{11}}{1.4\times10^{12}})$ = 0.62 (m s^{-2}) 4 × 3

one error (3 × 3)

two errors (2 × 3)

partial answer (3)

The mass of the *New Horizons* spacecraft is 450 kg. Calculate the weight it would have on the surface of Pluto. **6 or 3**

(weight = mg = 450 × 0.62 =) 279 (N) // answer consistent with g above 6

partial answer (3)

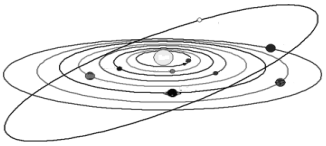
The closest the spacecraft got to Pluto was 11000 km from the surface of the planet. Would you expect its weight at this position to be greater or less than it would be at the surface? Explain your answer. **2 × 3**

less 3

further away (from Pluto) 3

The Earth is surrounded by a layer of air, called its atmosphere, which exerts a pressure on the surface of the planet. Explain why Pluto's atmosphere exerts a very low pressure on its surface. **3**

small g, little atmosphere, Pluto has a small mass (relative to the earth), etc. 3



The *New Horizons* spacecraft used a radioactive isotope to generate electricity, instead of the solar panels used on most spacecraft.

Suggest a reason why solar panels were unsuitable in this case. **5 or 3**

Pluto is too far from the sun, they wouldn't generate much energy 5

partial answer (3)

Question 7 **56**

Sound and light travel as waves. Sound travels as a <u>longitudinal wave</u> whereas light travels as a <u>transverse wave</u>.

Explain the underlined terms. **2(4 or 2)**

longitudinal waves: the vibration (of the medium) is in the same direction of motion of the wave 4
partial answer (2)
transverse waves: the vibration (of the medium) is perpendicular to the direction of motion of the wave 4
partial answer (2)
marks may be obtained from a diagram

Describe a laboratory experiment which demonstrates that sound requires a medium to travel through. **4 × 3**

apparatus: bell jar, electric bell / phone, battery, vacuum pump any two 2 × 3
procedure: turn on pump / remove the air 3
observation/conclusion: no sound heard when air removed, so sound needs a medium 3

Total internal reflection is the basis of operation of optical fibres.

(*i*) With the aid of a labelled diagram, explain how total internal reflection occurs. **6 + 3**

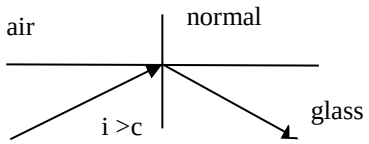


diagram with explanation of TIR 6 + 3
diagram / explanation (6)
partial answer (3)
NOTE: no labels, deduct 2

(*ii*) State two uses of optical fibres. **2 × 3**

telecommunications, endoscope, correct specific ornament/toy, to supply light to inaccessible places, etc. any two 2 × 3
partial answer e.g. cars, medicine, decorations, toys (3)

(*iii*) The refractive index of a material in an optical fibre is 1.44. Calculate the minimum angle at which light can strike the sides of the fibre and still be transmitted through the fibre. **3 × 3**

$(n = \frac{1}{\sin C} = 1.44 \qquad \sin C = 0.694) \qquad C = 43.98°$ 3 × 3

one error (2 × 3)
partial answer e.g. correct equation (3)

The picture shows a sound-level meter, which is used to measure sound intensity level.

(*iv*) What is the unit of sound intensity level? **6 or 3**

Bel / B // decibel / dB 6
partial answer e.g. defines sound intensity level (3)

(*v*) Why might a sound-level meter be used in a workplace? **6 or 3**

to ensure the sound level is below (permitted) limit, to protect hearing 6
partial answer e.g. to measure the sound level, to measure loudness (3)

Question 8 **56**

Define *voltage* and *resistance*. **6 + 3**

potential energy between two points on a circuit / potential difference / $^{W}/_{Q}$ / electromotive force
the ratio of the potential difference to the current / $^{V}/_{I}$

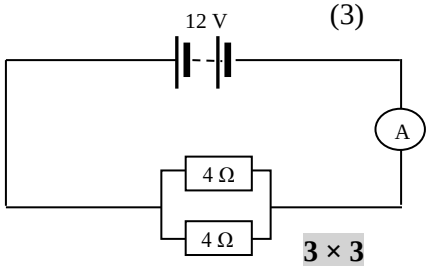
two correct 6 + 3
one correct (6)
partial answer (3)

Name an instrument used to measure each of these quantities. **2 × 3**

voltmeter / multimeter 3
ohmmeter / multimeter 3
partial answer e.g. ammeter (3)

Name a source of voltage. **6 or 3**

battery / cell /power supply /generator / thermocouple / solar panel 6
partial answer e.g. wall socket (3)



The diagram above shows a circuit with a 12 V d.c. power supply, an ammeter, and two 4 Ω resistors connected in parallel.

Calculate

(*i*) the total resistance of the circuit **3 × 3**

$\left(\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}=\frac{1}{4}+\frac{1}{4}=\frac{1}{2}\right) \Rightarrow$ R = 2 (Ω) 3 × 3

one error e.g. $\frac{1}{R}=\frac{1}{2}$ (2 × 3)

partial answer e.g. correct equation (3)

(*ii*) the current flowing through the ammeter **6 or 3**

$\left(I=\frac{V}{R}=\frac{12}{2}=\right)$ 6 (A) // answer consistent with above 6

partial answer e.g. correct equation (3)

(*iii*) the current flowing through each resistor **6 or 3**

$(I_1=\frac{V_1}{R_1}=\frac{12}{4}=)$ 3 (A) // answer consistent with above 6

partial answer e.g. correct equation (3)

One effect of an electric current is the heating effect. Name the two other effects of an electric current. **2 × 3**

chemical 3
magnetic 3

Describe an experiment to demonstrate one of these two effects. **2 × 3 + 2**

apparatus: power source, closed circuit, solenoid, compasses / iron filings any two 3
procedure: turn on the current 3
observation/conclusion: compass direction changes / iron filings rearrange etc. 2
accept valid alternatives e.g. Hofmann voltameter
a labelled diagram may merit full marks

Question 9 **56**

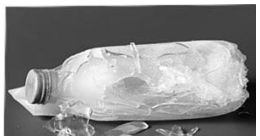
What is meant by *latent heat*? **6 or 3**

heat required to change state (without changing its temperature) 6

partial answer (3)

Name an instrument used to measure temperature. **3**

thermometer 3



A glass bottle is filled with 0.75 kg of water at a temperature of 20 °C. The bottle is then placed in a freezer, which freezes the water and cools it to −15 °C. Calculate the energy removed from the water to

(*i*) reduce its temperature to 0 °C **3 × 3**

($E = mc\Delta\theta$ = 0.75 × 4200 × 20 =) 63000 (J) 3 × 3

one error (2 × 3)

partial answer e.g. correct equation (3)

(*ii*) convert the water at 0 °C to ice at 0 °C **3 × 3**

($E = ml$ = 0.75 × 3.3 × 10^5 =) 247500 (J) 3 × 3

one error (2 × 3)

partial answer e.g. correct equation (3)

(*iii*) to cool the ice at 0 °C to ice at −15 °C. **2 × 3**

($E = mc\Delta\theta$ = 0.75 × 2200 × 15 =) 24750 (J) 2 × 3

partial answer e.g. one error, correct equation (3)

The power rating of the freezer is 300 W. How long will it take for the freezer to remove 9000 J of energy from the water? **5 or 3**

($t = W \div P$ = 9000 ÷ 300 =) 30 s 5

partial answer e.g. correct equation (3)

As the water freezes, the glass bottle cracks and shatters.
Explain why this occurs. **6 or 3**

water expands / glass contracts 6

partial answer (3)

The freezer is an example of a heat pump.
Outline the operation of a heat pump. **6 + 2 × 3**

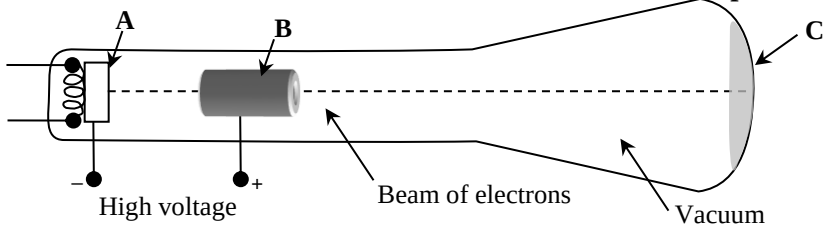
liquid evaporates
liquid needs heat to evaporate // takes heat from fridge contents
releases heat (at back)
gas condenses
reference to latent heat

any three lines 6 + 2 × 3
two lines (6 + 3)
any line (6)

partial answer (3)

Question 10 **56**

X-ray tubes and cathode ray tubes are practical applications of thermionic emission. Thermionic emission causes the emission of electrons, which are sub-atomic particles.



The diagram shows a simple cathode ray tube, which produces a beam of electrons by thermionic emission.

(*i*) State two properties of the electron. Name another sub-atomic particle. **2 × 3 + 3**

(negatively) charged, deflected by electric fields, deflected by magnetic fields, fundamental particle, small mass, outside nucleus, etc.

any two 2 × 3
any one (3)

proton, neutron, neutrino, quark, etc. 3

(*ii*) Name the parts labelled A, B, and C in the diagram. **3 × 3**

A: cathode 3
B: anode 3
C: screen 3
three correct labels, incorrect order (2 × 3)
partial answer e.g. 2 correct labels in incorrect order (3)

(*iii*) State the function of any two of these parts. **6 + 3**

cathode emits electrons / particles
anode attracts / focuses /accelerates (electrons)
screen lights up / shows presence (of electrons) two lines correct 6 + 3
one line correct (6)
partial answer (3)

(*iv*) How could the beam of electrons be deflected? **6 or 3**

electric field / electrode / magnetic field / magnet / X-Y plates 6
partial answer (3)

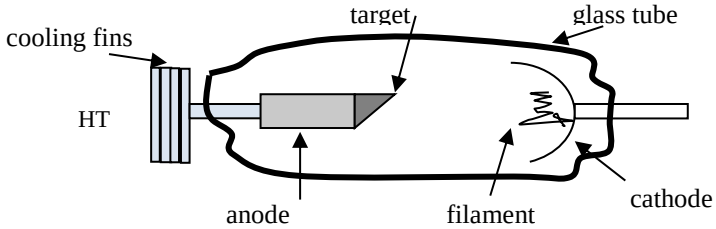
(*v*) Why is it important to have a vacuum inside a cathode ray tube? **6 or 3**

electrons not blocked / easier to pass through / electrons not absorbed 6
partial answer (3)

(*vi*) State one use of a cathode ray tube. **3**

monitors, TV (screen), computer screen, etc. 3

Electrons are produced by thermionic emission in an X-ray tube also.
Draw a sketch of an X-ray tube. **3 × 3 + 2**



heater, cathode, anode, target, high voltage any three 3 × 3
detail e.g. correct arrangement, coolant, shielding, vacuum, window 2
partial answer (3)

Why are lead aprons often worn when using an X-ray tube? **(3)**

protect body, safety 3

Question 11 **56**

Experimentum crucis

Once he returned to Cambridge from the country in 1667, Newton began to gain honours with startling rapidity and became the second holder of the Lucasian Professorship in Mathematics, a position later held by Stephen Hawking. This new job obliged Newton to give occasional lectures but he was also able to spend much more time on experiments.

To isolate a single colour (or at least what the eye sees as a colour – a spectrum in fact consists of an innumerable range of colours, each blending into the next), he put a card with a hole in it next to a prism, only letting through a narrow band of light. Not only did he confirm his view that when this beam was passed through a second prism no different colours were produced – red light remained red, blue remained blue and so on – he discovered that red coloured light was bent much less by the prism than blue light. The degree of bending, the refraction, varied as he moved through the different colours.

He later referred to this discovery as the *experimentum crucis*, the crucial experiment, emphasising its significance as a turning point in the understanding of the nature of light. He had found something fundamental and new - that light was made up of colours that were distinct entities, impossible to change from one into the other, each bent differently by a prism. For good measure, his experiment explained why a prism worked at all. When a beam of light hit an ordinary block of glass there was no rainbow produced. As the light passed from air to glass it was true that the blue light would bend further than the red, splitting it out, but when it reached the far side of the block it would move back the other way an equal amount and the result would be to recombine the colours. The prism's triangular faces meant that the two opportunities to bend - towards the vertical of the first face and away from the vertical of the second - both resulted in movement in the same direction. The colours remained separate. (Adapted from *Light Years - The Extraordinary Story of Mankind's Fascination with Light*, Brian Clegg, Icon Books, 2015).

(***a***)	**What word is used to describe the bending of light by a prism?**	**7 or 4**
	refraction	7
	partial answer	(4)
(***b***)	**What does the spectrum of light consist of?**	**7 or 4**
	range of colours, seven colours	7
	partial answer	(4)
(***c***)	**Which colour of light is bent the most?**	**7**
	violet / blue	7
(***d***)	**Draw a diagram to show how a spectrum can be produced using a prism.**	**7 or 4**
	diagram to include white light source, prism and screen/spectrum	7
	partial answer	(4)
(***e***)	**What was the significance of Newton's experiment?**	**7 or 4**
	light is made up of colours	7
	partial answer e.g wave theory	(4)
(***f***)	**Without using a prism, how else can a spectrum be produced?**	**7 or 4**
	(diffraction) grating, CD, etc.	7
	partial answer	(4)
(***g***)	**Why is a spectrum not produced by an ordinary block of glass?**	**7 or 4**
	because it splits (on entering) and recombines (on leaving) //	
	faces not triangular / sides parallel	7
	partial answer	(4)
(***h***)	**Name another field of physics for which Newton is famous.**	**7 or 4**
	mechanics / gravitation / heat	7
	partial answer	(4)

Question 12 **56**

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

(*a*) Define *kinetic energy* and *potential energy*. **2 × 3**

energy due to motion / ½ mv^2 3

energy due to position / energy due to state / mgh 3

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

Students carried out an experiment to investigate how to protect a falling egg from breaking. They observed the results when an egg of mass 52 g was dropped from a height of 2 m, when protected and unprotected.

(*i*) Calculate the potential energy of the egg before it was dropped. **6 or 3**

(PE = mgh = 0.052 × 9.8 × 2 =) 1.02 (J) 6

partial answer e.g. correct equation (3)

(*ii*) Calculate the velocity of the egg as it hit the ground. **6 or 3**

($\frac{1}{2}mv^2 = mgh \Rightarrow v^2 = 2gh = 2 \times 9.8 \times 2 = 39.2 \Rightarrow v$ =) 6.26 (m s^{-1}) 6

partial answer e.g. correct equation (3)

Suggest how the egg could be protected from breaking when it hits the ground. **6 or 3**

place balls of paper on the ground under it to give it a soft landing, etc. 6

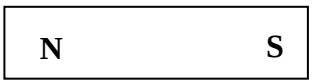
partial answer (3)

State one everyday application of the principle behind the protection of the egg. **4 or 2**

air bags in cars, lunar landing, on the ground for safety when workers are up on a height, etc. 4

partial answer (2)

(*b*) The diagram shows a bar magnet.



(*i*) Copy the diagram and show on it the magnetic field lines around the magnet. **6 or 3**

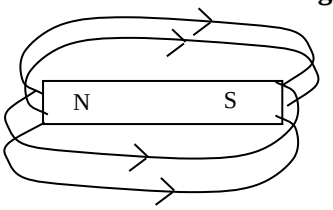


diagram to show: magnet, two field lines, correct direction on lines 6

partial answer e.g. incomplete diagram (3)

(*ii*) Describe an experiment to plot the magnetic field lines around the magnet. **4 × 3**

apparatus: magnet 3

(plotting) compass // iron filings 3

procedure: use the apparatus to locate the field lines e.g. (place the compass on the paper and) mark the dots and repeat // sprinkle filings 3

detail: e.g. join the dots / show field lines / the lines go from north to south / field lines are concentrated at the magnet's poles / tap filings 3

marks may be obtained from a diagram

(*iii*) Name a metal that is attracted to a magnet. **4 or 2**

nickel, iron, cobalt, steel, alnico, named magnetic alloy, etc. 4

partial answer e.g. alloy (2)

(*iv*) State two practical uses of a magnet. **2 × 3**

compass, keep fridge door closed, electric bell, electric motor, transformers, electromagnets, moving coil meters, loudspeakers, etc.

any two 2 × 3

any one (3)

(*c*) A ring circuit is used in domestic wiring.

(*i*) State one advantage of using of a ring circuit when wiring a house. **6 or 3**

fewer sockets, fewer safety devices, cables carry less current, etc. 6

partial answer (3)

(*ii*) Earthing is a safety measure included in domestic circuits.

What is meant by earthing? **3**

(wire) connecting (the metal body of appliances) to the earth / ground 3

How does earthing contribute to safety? **6 or 3**

in the event of a fault occurring the current will flow to earth 6

partial answer (3)

(*iii*) Name one other safety device used in domestic wiring. **4**

fuse, circuit breaker, MCB, RCD 4

(*iv*) In a standard domestic three-pin plug, the live wire is covered in brown plastic.

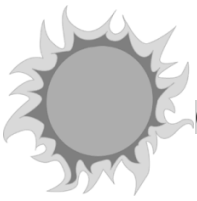
Name the other two wires and state the colour associated with each of them. **3 × 3**

neutral 3

earth 3

neutral is blue and the earth is green-yellow 3

partial answer (3)



(*d*) *Nuclear fusion* is the source of the Sun's energy.

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

combining of two nuclei with the release of energy / radiation 6

partial answer (3)

(*ii*) Name the other type of nuclear reaction used in nuclear power stations. **6 or 3**

fission 6

partial answer (3)

(*iii*) State one advantage and one disadvantage of each of these sources of nuclear energy. **4 × 3**

fusion advantage: H and He atoms are plentiful, fusion produces lots of energy, little waste, etc. 3

fusion disadvantage: very high temperatures needed, uneconomical at present, more difficult to control and sustain, etc. 3

fission advantage: (breeder reactors) can make their own fuel, can generate radioisotopes (for medicine), etc. 3

fission disadvantage: dangerous raw material, dangerous waste, waste storage, security problems, etc. 3

(*iv*) Name the scientist whose equation $E = mc^2$ explained why a large amount of energy is available from a small mass of fuel in nuclear reactions. **4 or 2**

Einstein 4

partial answer e.g. named nuclear scientist (2)

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