Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2022

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.

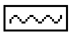
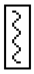
4. The descriptions, methods and definitions in the scheme are not exhaustive and alternative valid answers are acceptable.

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.

7. A zero should only be recorded when the candidate has attempted the question but does not merit marks. If a candidate does not attempt a question (or part of) examiners should record NR.

8. Examiners are expected to annotate parts of the responses as directed at the marking conference. (See below.)

Symbol	**Name**	**Use**
✗	Cross	Incorrect element
✓	Tick	Correct element (0 marks)
✓ n	Tick_n	Correct element (n marks)
	Horizontal wavy line	To be noticed
	Vertical wavy line	Additional page
-1	−1	−1
^	^	Missing element

9. Bonus marks at the rate of 10% of the marks obtained will be given to a candidate who answers entirely through Irish and who obtains 75% or less of the total mark available (i.e. 228 marks or less). In calculating the bonus to be applied decimals are always rounded down, not up ¬ e.g., 4.5 becomes 4; 4.9 becomes 4, etc. See below for when a candidate is awarded more than 228 marks.

Marcanna Breise as ucht freagairt trí Ghaeilge

Léiríonn an tábla thíos an méid marcanna breise ba chóir a bhronnadh ar iarrthóirí a ghnóthaíonn níos mó ná 75% d'iomlán na marcanna.

N.B. Ba chóir marcanna de réir an ghnáthráta a bhronnadh ar iarrthóirí nach ngnóthaíonn níos mó ná 75% d'iomlán na marcanna don scrúdú. Ba chóir freisin an marc bónais sin **a shlánú síos**.

Tábla 304 @ 10%
Bain úsáid as an tábla seo i gcás na n-ábhar a bhfuil 304 marc san iomlán ag gabháil leo agus inarb é 10% gnáthráta an bhónais.

Bain úsáid as an ngnáthráta i gcás 228 marc agus faoina bhun sin. Os cionn an mharc sin, féach an tábla thíos.

Bunmharc	Marc Bónais
229 - 230	22
231 - 234	21
235 - 237	20
238 - 240	19
241 - 244	18
245 - 247	17
248 - 250	16
251 - 254	15
255 - 257	14
258 - 260	13
261 - 264	12
265 - 267	11

Bunmharc	Marc Bónais
268 - 270	10
271 - 274	9
275 - 277	8
278 - 280	7
281 - 284	6
285 - 287	5
288 - 290	4
291 - 294	3
295 - 297	2
298 - 300	1
301 - 304	0

1. A student carried out an experiment to measure the velocity of an object.

(*i*) Draw a labelled diagram of the apparatus used to measure constant velocity.

runway / air-track

car / rider

ticker-tape / light-gate / timer **[6 + 3 + 3]**

[–1 if no label present on diagram]

(*ii*) Indicate on the diagram what distance the student measured.

length of tape / length of rider or card / distance travelled by car/rider **[3]**

(*iii*) Describe how the student measured the time.

number of gaps × 0.02 s / from (electronic) timer **[3]**

(*iv*) State the formula used to calculate the velocity.

$s \div t$ **[6]**

[accept partial answer for 3]

The student then used the apparatus to measure the acceleration of the object.

(*v*) What changes did the student make to the apparatus?

changed slope / applied force / second light-gate **[4]**

(*vi*) What measurements did the student take to calculate acceleration?

two distances/times/velocities / distance or time between measurements **[4]**

(*vii*) How did the student use these measurements to calculate acceleration?

$(v - u) \div t$ or $(v^2 - u^2) \div 2s$ **[4]**

[accept partial answer for 2]

(*viii*) State two precautions that could be taken to improve the accuracy of either of these experiments.

e.g. polish, oil, remove dirt, change slope, repeat, increased sensitivity of timer, avoid error of parallax etc. **[3 + 1]**

2. A student carried out an experiment to verify Snell's Law and used her measurements to calculate the refractive index (*n*) of a material. She measured the angle of incidence *i* and the corresponding angle of refraction *r*. She repeated this for a different values of *i*.

Her results are shown in the table below.

i (degrees)	30	40	50	60
r (degrees)	19	25	31	35

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

transparent block

ray-box / laser / pins

detail e.g. paper, ruler, pencil, protractor, etc. **[6 + 3 + 3]**

[–1 if no label present on diagram]

(*ii*) On your diagram, label the angles measured by the student.

both angles labelled **[6]**

[accept partial answer for 3]

(*iii*) Name the instrument used to measure these angles.

protractor **[3]**

(*iv*) State the formula used to calculate *n.*

sin *i* ÷ sin *r* **[4]**

[accept partial answer for 2]

(*v*) Use all of the results in the table to calculate an average value for *n*.

one calculation of *n* **// graph of sin *i* against sin *r*** **[3]**

average calculated **// slope calculated** **[3]**

(*vi*) Do your calculations verify Snell's law? Explain your answer.

yes [or answer consistent with calculations] **[3]**

explanation, e.g. calculations all close to average, straight line through origin **[3]**

(*vii*) State one precaution used to improve the accuracy of the experiment.

e.g. thinner pencil, avoid error of parallax, etc. **[3]**

3. A student carried out an experiment to investigate how the fundamental frequency *f* of a stretched string changes with length *l*. The student set a length of string vibrating and adjusted the length until resonance occurred. The tension of the string was kept constant throughout the experiment.

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

sonometer / stretched string **[3]**

detail, e.g. metre stick, tuning fork, bridge, paper rider, etc. **[3]**

[–1 if no label present on diagram]

(*ii*) Indicate on your diagram the length of string the student measured.

length between two bridges / any valid length **[3]**

(*iii*) Name the instrument used to measure length.

sonometer / metre stick **[3]**

(*iv*) Explain why the tension of the string must be kept constant.

frequency depends on tension *[state or imply]* **[3]**

The student recorded the following results.

f (Hz)	256	320	341	427	480	512
l (cm)	22	18	17	13	12	11
$^1/_l$ (cm^{-1})						

(*v*) How did the student find the frequency values?

from tuning forks / from signal generator **[3]**

(*vi*) Describe how the student knew that resonance had occurred.

paper rider jumps / loud sound **[4]**

[accept partial answer for 2]

(*vii*) In your answerbook, copy and complete the table above.

$^1/_l$ (cm^{-1})	**0.045**	**0.056**	**0.059**	**0.077**	**0.083**	**0.091**

[6 × 1]

(*viii*) Use the data to plot a graph of *f* against $^1/_l$.

labelled axis **[3]**

points plotted **[6 × 1]**

line of best fit **[3]**

4. A student carried out an experiment to measure *c*, the specific heat capacity of water.
He added heat energy to water in a copper calorimeter.

The following results were recorded.

Mass of empty copper calorimeter	= 0.0745 kg
Mass of calorimeter and cold water	= 0.1498 kg
Initial temperature of cold water	= 18 °C
Final temperature of water	= 23 °C
Heat energy added	= 1703 J

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

calorimeter, water, appropriate source of heat, thermometer, mass balance, joulemeter, detail e.g. lagging, lid, stirrer etc. **[*any* 3 × 3]**

[–1 if no label present on diagram]

(*ii*) How did the student supply the heat energy?

joulemeter / hot copper / heating element *[state or imply]* **[3]**

(*iii*) Calculate the mass of the water.

0.1498 – 0.0745 = 0.0753 kg **[6]**

[accept partial answer for 3]

(*iv*) Calculate the increase in temperature of the calorimeter and cold water.

23 – 18 = 5 °C **[6]**

[accept partial answer for 3]

(*v*) State the formula used to calculate the heat gained by a material as it changes temperature.

$mc\Delta\theta$ **[4]**

[accept partial answer for 2, e.g. $C\Delta\theta$]

(*vi*) Use your answers for (*iii*), (*iv*) and (*v*) to calculate *c,* the specific heat capacity of water.

1703 = (0.0745 × 390 × 5) + (0.0753 × *c* × 5) **[6 + 2 + 2]**

c = 4137.4 [J kg^{-1} K^{-1}] **[2]**

Note: Heat energy added = Heat energy gained by water + calorimeter.

(*specific heat capacity of copper = 390 J kg^{-1} K^{-1}*)

5. In an experiment to verify Joule's law, a constant current I was passed through a heating coil immersed in water and the rise in temperature $\Delta\theta$ was recorded. This procedure was repeated for a number of different currents. The mass of the water and the length of time for which the current was flowing were both kept constant.

The student recorded the following results.

I (*A*)	1	1.5	2	2.5	3	3.5
I^2 (A^2)						
$\Delta\theta$ (°C)	1.2	2.7	4.8	7.5	10.8	14.7

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

container, water, heating coil, ammeter/multimeter, thermometer, detail e.g. mass balance, stopwatch, lagging, lid, stirrer etc. **[*any* 3 × 3]**

[–1 if no label present on diagram]

(*ii*) Why were the mass and the time kept constant?

$\Delta\theta$ depends on mass and/or time *[state or imply]* **[3]**

(*iii*) In your answerbook, copy and complete the table above.

I^2 (A^2)	**1**	**2.25**	**4**	**6.25**	**9**	**12.25**

[6 × 1]

(*iv*) Use all of the data to plot a graph of I^2 against $\Delta\theta$.

labelled axis **[3]**

points plotted **[6 × 1]**

line of best fit **[3]**

(*v*) Use your graph to find the current that caused a change in temperature of 6 °C.

reading for I^2 [≈ 5] **[3]**

I ≈ 2.2 A **[3]**

[accept partial answer for 3, e.g graph not used]

(*vi*) Explain how your graph verifies Joule's law.

I^2 proportional to $\Delta\theta$ **[4]**

[accept partial answer for 2]

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

(*a*) State Newton's first law of motion.

a body remains at rest [or moving at constant velocity] unless an [unbalanced, external] force acts on it **[7]**

[accept partial answer for 4, e.g Newton's second law of motion]

(*b*) A boy applies a force of 20 N to pull his sleigh for 150 m. Calculate the work done by the boy.

20 × 150 = 3000 J **[7]**

[accept partial answer for 4]

(*c*) What is the difference between heat and temperature?

heat is a form of energy / temperature is a measure of hotness ***[state or imply]*** **[7]**

[accept partial answer for 4]

(*d*) Draw a labelled diagram to show how light travels through an optical fibre.

total internal refraction shown **[7]**

[–1 if no label present on diagram]

[accept partial answer for 4]

(*e*) Describe how to charge an electroscope.

touch with charged object / bring charged object close and earth electroscope **[7]**

[accept partial answer for 4]

(*f*) Two resistors of resistance 4 Ω and 7 Ω are connected in series.
Calculate the combined resistance of the two resistors.

4 + 7 = 11 Ω **[7]**

[accept partial answer for 4]

(*g*) When the frequency of a sound wave increases, its pitch also increases. What is observed to happen to a sound when its amplitude increases?

it gets louder **[7]**

[accept partial answer for 4]

(*h*) Describe how to show the magnetic field of a bar magnet.

distribute iron filings / move compass **[7]**

[accept partial answer for 4]

(*i*) Name the three primary colours of light.

red, blue, green **[4 + 2 + 1]**

(*j*) What is meant by nuclear fission?

splitting a nucleus [by a neutron, releasing energy] **[7]**

[accept partial answer for 4]

(*k*) A fuse is a safety device used in an electrical plug. Describe how a fuse works.

melts/breaks when current is too high **[7]**

[accept partial answer for 4]

(*l*) Explain what is meant by the half-life of a radioactive sample.

the time for half the sample to decay / the time for its activity to halve **[7]**

[accept partial answer for 4]

7. A train of mass 420000 kg started from rest and accelerated to a velocity of 25 m s^{-1} in a time of 6 minutes.

(*i*) What is meant by velocity?

rate of change of displacement / speed in a given direction / *s ÷ t* **[6]**

[–1 if "distance" used instead of "displacement"]

[accept partial answer for 3]

(*ii*) Convert 6 minutes into seconds.

6 × 60 = 360 s **[6]**

[accept partial answer for 3, e.g. reference to 60 s in a minute]

(*iii*) Calculate the acceleration of the train. Include units in your answer.

25 ÷ 360 = 0.069 **[4]**

[accept partial answer for 2, e.g. a = (v-u)/t]

m s^{-2} **[2]**

(*iv*) Calculate the force required to accelerate the train.

420000 × 0.069 = 29166.7 N **[6]**

[accept partial answer for 3, e.g. F = ma]

(*v*) Calculate the distance the train travelled in 6 minutes.

4500 m **[6]**

[accept partial answer for 3, e.g. s = ut + ½at²]

The train then maintained this speed of 25 m s^{-1} for a further 15 minutes.

(*vi*) Calculate the distance the train travelled during this 15 minute interval.

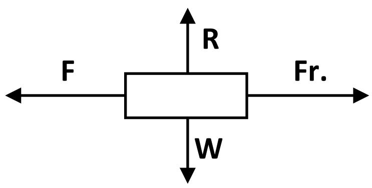
25 × 15 × 60 = 22500 m **[6]**

[accept partial answer for 3, e.g. formula for distance]

(*vii*) Draw a labelled diagram to show the forces acting on the train while it is moving with constant speed.

four correct forces **[9]**

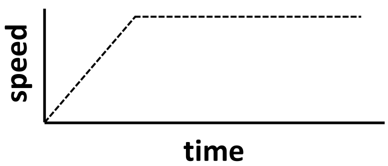
[–1 for each omitted force]



(*viii*) An object may have a constant speed but not a constant velocity. Explain why.

it is changing direction **[3]**

(*ix*) Draw a speed-time graph for the train during the first 21 minutes of its journey.

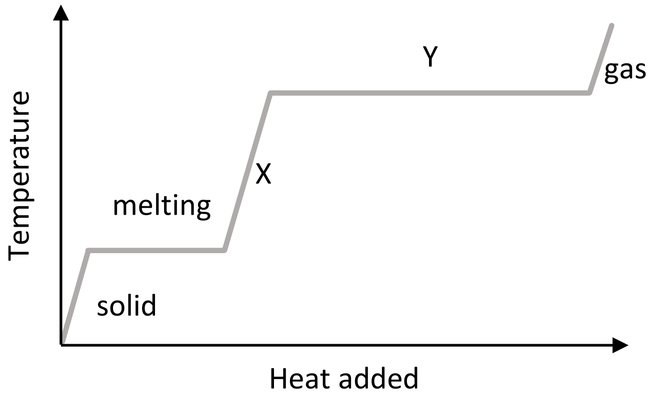


labelled axis **[2]**

correct shape **[6]**

[for shape, accept partial answer for 3]

8. The graph shows how the temperature and state of water change as the water is heated up.



(*i*) Explain the shape of the graph at part X.

increase in temperature / no change of state **[6]**

[accept partial answer for 3]

(*ii*) Explain the shape of the graph at part Y.

change of state / evaporation / no change in temperature **[6]**

[accept partial answer for 3]

(*iii*) Describe how the energy could have been supplied to the water.

e.g. joulemeter, element, coil, electricity, hot plate etc.

detail, e.g. in the water, under the container of water as appropriate **[6 + 3]**

[accept partial answer for 3]

(*iv*) Ice has a latent heat of 330000 J kg^{-1}. Calculate how much energy is required to change 0.2 kg of ice to water.

330000 × 0.2 = 66000 J **[6]**

[accept partial answer for 3]

(*v*) Explain why a steam burn is more dangerous than a burn from boiling water.

steam has more energy / steam may have higher temperature **[6]**

[accept partial answer for 3]

The temperature of the water needs to be measured throughout this experiment. It is measured using a thermometer.

(*vi*) A thermometer uses a particular thermometric property to measure temperature. What is meant by a thermometric property?

one that changes [measurably] with heat/temperature **[5]**

[accept partial answer for 3]

(*vii*) State two examples of thermometric properties.

e.g volume, emf, pressure, height, resistance etc. **[4 + 2]**

(*viii*) Describe, with the aid of labelled diagram, a laboratory experiment to calibrate a thermometer.

calibrated thermometer **[3]**

uncalibrated thermometer **[3]**

source of heat **[3]**

method **[3]**

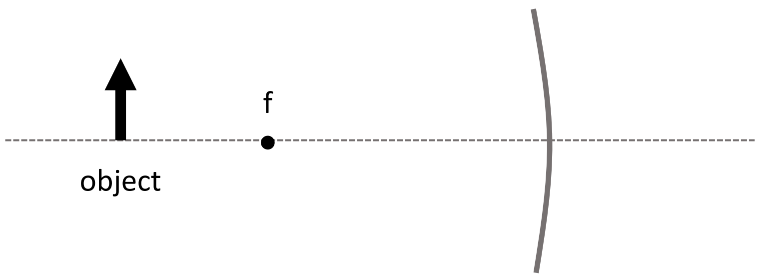
[–1 if no label present on diagram]

9. When light is reflected from a concave mirror, the image produced may be real or virtual.

(*i*) What is meant by reflection?

rebounding of a wave off a surface **[3]**

(*ii*) In your answerbook, copy and complete the ray diagram below to show how a magnified image is formed in a concave mirror.



first reflected ray **[5]**

second reflected ray **[2]**

intersection of rays **[2]**

(*iii*) The image formed is real. Explain what is meant by a real image.

one formed by the intersection of rays / one formed on a screen **[6]**

[accept partial answer for 3]

The object is 20 cm in front of the concave mirror. The mirror has a focal length of 12 cm.

(*iv*) Calculate the position of the real image formed.

$1/u + 1/v = 1/f$ **[6]**

substitution **[3]**

v = 30 cm **[3]**

[accept partial answer for 3]

(*v*) The object has a height of 4 cm. Calculate the height of the image.

$m = v/u = 1.5$ **[3]**

image height = 4 × 1.5 = 6 cm **[3]**

[accept partial answer for 3]

(*vi*) State one use for a concave mirror.

e.g. shaving, dentistry, headlights, searchlights, satellite dishes, etc. **[4]**

[accept partial answer for 2]

Light is also reflected by convex mirrors.

(*vii*) Sketch a convex mirror. Indicate which side of the mirror reflects light.

shape **[3]**

side **[3]**

(*viii*) The image produced in a convex mirror is always virtual. Explain what is meant by a virtual image.

one formed by the apparent intersection of rays / one not formed on a screen **[6]**

[accept partial answer for 3]

(*ix*) State one use for a convex mirror.

e.g. cars, shops, roads, etc. **[4]**

[accept partial answer for 2]

10. When a person sings, their vocal chords vibrate. These vibrations travel through the air to the listener's ears.

(*i*) Sound is an example of a mechanical wave which therefore needs a medium to travel through. Describe an experiment to show that sound is a mechanical wave.

apparatus, e.g. source of sound, bell jar **[3]**

method 1: e.g. place source of sound in jar **[3]**

method 2: e.g. turn on vacuum pump **[3]**

observation **[3]**

(*ii*) Sound is also an example of a longitudinal wave. What is a longitudinal wave?

wave displacement is parallel to direction of wave **[6]**

[accept partial answer for 3]

Sound waves can undergo reflection, refraction, diffraction and interference.

(*iii*) A doorway may cause a sound wave to diffract but it will not cause a light wave to do so. Explain why.

appropriate reference to width of doorway and wavelength of sound/light **[6]**

[accept partial answer for 3]

(*iv*) Describe an experiment to show that sound waves undergo interference.

apparatus, e.g. two speakers (emitting the same sound) **[3]**

method, e.g. walk between the speakers **[3]**

observation **[3]**

(*v*) Sound waves do not undergo polarisation but light waves do. What is meant by polarisation?

wave vibrations restricted to one plane **[6]**

[accept partial answer for 3]

The human ear is most sensitive to sounds with frequencies between 2 kHz and 4 kHz. One reason for this is that sounds in this range can cause resonance to occur in the ear canal.

(*vi*) What is meant by resonance?

transfer of energy between two objects of similar natural frequency **[6]**

[accept partial answer for 3]

The ear canal can be thought of as a pipe open at one end.

(*vii*) Draw a labelled diagram to show the first position of resonance for a sound wave in a pipe open at one end.

node at closed end, anti-node at open end, no other nodes or antinodes **[6]**

[–1 if no label present on diagram]

[accept partial answer for 3]

(*viii*) The frequency of a sound wave is 2800 Hz and it has a wavelength of 0.12 m. Calculate the speed of the wave.

$2800 \times 0.12 = 336$ m s^{-1} **[5]**

[accept partial answer for 3, e.g. $c = f\lambda$]

11. Benjamin Franklin began experimenting with electricity during the 18th century.

(*i*) What is electric current?

flow of charge **[6]**

[accept partial answer for 3]

(*ii*) Name an instrument used to measure electric current.

ammeter /galvanometer / multimeter **[6]**

[accept partial answer for 3, e.g. voltmeter, ohmmeter]

(*iii*) A torch contains a battery, a light bulb and a switch. Draw a circuit diagram to show how these components are connected in a torch.
(You may refer to the electrical circuit symbols on pages 72 to 78 of the booklet of *Formulae and Tables*.)

component symbols **[3 × 1]**

connected in series **[3]**

(*iv*) The wires in a circuit are made of metal. Explain why.

conductor **[3]**

(*v*) Name the subatomic particle that is the charge carrier in a metal.

electron **[6]**

[accept partial answer for 3, e.g. proton, neutron]

(*vi*) A charge of 30 C passes through a wire in a time of 6 s. Calculate the current flowing in the wire.

30 ÷ 6 = 5 A **[6]**

[accept partial answer for 3]

(*vii*) The wire has a resistance of 3 Ω. Calculate the potential difference (voltage) across the wire.

5 × 3 = 15 V **[6]**

[accept partial answer for 3]

(*viii*) The 3 Ω wire is connected in parallel with another wire of resistance 2 Ω. Calculate the total resistance of the two wires in parallel.

$1/R_1 + 1/R_2 = 1/R_T$ **[3]**

substitution **[3]**

$R_T = 1.2\ \Omega$ **[3]**

[accept partial answer for 3]

A piece of wire of length 1.5 m has a resistance of 12 Ω.

(*ix*) What is the resistance of a 3 m piece of the same wire?

24 Ω / double **[4]**

[accept partial answer for 2]

(*x*) State the relationship between the resistance of a wire and its cross-sectional area.

inversely proportional **[4]**

[accept partial answer for 2]

12. The Irish physicist George Stoney is most famous for introducing the term *electron*.

(*i*) State two properties of the electron.

e.g. negative charge, small mass etc. **[4 + 4]**

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

(*ii*) Describe an experiment to demonstrate the photoelectric effect.

apparatus [e.g. electroscope, zinc plate, uv lamp] **[3]**

method **[3]**

observation **[3]**

To ensure the photoelectric effect occurs, the light must be of a suitable frequency to release the electrons. The frequency of the light must be above the threshold frequency.

(*iii*) Describe what happens if the frequency of the incident light is below the threshold frequency.

photoelectric effect does not occur **[3]**

(*iv*) The threshold frequency for zinc is 6.5×10^{14} Hz.

(*a*) Calculate the wavelength of light of this frequency.

$\mathbf{(3 \times 10^{8}) \div (6.5 \times 10^{14}) = 4.6 \times 10^{-7}}$ **m** **[6]**

[accept partial answer for 3]

(*b*) Calculate the energy of a photon of this frequency.

$\mathbf{(6.6 \times 10^{-34}) \times (6.5 \times 10^{14}) = 4.3 \times 10^{-19}}$ **J** **[6]**

[accept partial answer for 3]

X–ray production is the inverse process of the photoelectric effect. In an X–ray tube, X–rays are produced when high speed electrons hit a target.

(*v*) How are electrons produced in an X–ray tube?

thermionic emission / hot cathode **[6]**

[accept partial answer for 3]

(*vi*) How are electrons accelerated in an X–ray tube?

[high] voltage **[6]**

[accept partial answer for 3]

(*vii*) Tungsten is often used as the target in an X–ray tube. State one property of tungsten that makes it suitable to use as the target.

e.g. high melting point, high specific heat capacity **[6]**

[accept partial answer for 3]

(*viii*) What material could be used to ensure that the X–rays do not escape from the X–ray tube?

lead **[6]**

[accept partial answer for 3]

13. Read the following passage and answer the questions below.

Eclipses are among the most spectacular events in astronomy as they are events we can view without a telescope.

Total solar eclipses are the most dramatic of all eclipses. This is when the light from the Sun gets blocked by the Moon for a few minutes and day turns quickly into night. A lunar eclipse, when the Earth's shadow covers the Moon, is a gentler event. The full Moon gradually becomes fainter and redder over a period of a couple of hours. Both types of eclipse can be either total or partial. In a total eclipse, the Earth or the Moon gets completely in the way, while in a partial eclipse only a part of either the Earth or the Moon is in shadow.

Lunar eclipses are far more common than solar eclipses. This is because the Earth's shadow is bigger than the Moon's shadow. At the same time as the Earth's shadow blocks the Moon, some of the light from the Sun will pass through the Earth's atmosphere and then onto the Moon. The Sun's light is refracted as it passes through the Earth's atmosphere. The refracted light is then dispersed into the colours of the rainbow. These processes result in the Moon appearing red.

A rather spectacular version of an eclipse is a Super Blood Moon. This happens when there is an eclipse of the full Moon when it is at its closest to the Earth.

Solar eclipses happen when the Sun, Moon and Earth line up exactly. Total solar eclipses are very rare and only occur when all of the light from the Sun is blocked by the Moon. The last total solar eclipse visible from Ireland was in 1727 and the next one won't be until 2090.

Adapted from: rte.ie

(*i*) Describe what happens during a solar eclipse.

light from the Sun is blocked by the Moon **[7]**

[accept partial answer for 4]

(*ii*) Lunar eclipses are more common than solar eclipses. Explain why.

the Earth's shadow is bigger than the Moon's shadow **[7]**

[accept partial answer for 4]

(*iii*) The light from the Sun is refracted as it passes through the Earth's atmosphere. Explain what is meant by refraction.

bending of a wave as it travels from one medium to another **[7]**

[accept partial answer for 4]

(*iv*) Name two pieces of laboratory equipment that can be used to disperse light.

e.g. prism, diffraction grating etc. **[4 + 3]**

(*v*) The Moon has a mass of 7.3×10^{22} kg and a radius of 1.7×10^{6} m. Calculate *g*, the acceleration due to gravity on the Moon.

$(6.7 \times 10^{-11}) \times (7.3 \times 10^{22}) \div (1.7 \times 10^{6})^2 = 1.7 \text{ m s}^{-2}$ **[7]**

[accept partial answer for 4]

(*vi*) An astronaut weighs less on the Moon than she does on Earth. Distinguish between mass and weight.

mass is how much matter is in something / weight is force of gravity **[7]**

[accept partial answer for 4]

(*vii*) Infrared radiation lies just beyond red light in the electromagnetic spectrum, with a slightly longer wavelength. How can infrared radiation be detected?

e.g. blackened thermometer, [digital] camera etc. **[7]**

[accept partial answer for 4]

(*viii*) Name the type of electromagnetic radiation that has a slightly shorter wavelength than visible light.

ultraviolet / uv **[7]**

[accept partial answer for 4]

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

(*a*) A boy picks up a stone of mass 5 g and throws it vertically upwards with an initial velocity of 15 m s^{-1}. As the stone travels upwards, it loses kinetic energy.

(*i*) What is meant by kinetic energy?

energy due to motion **[3]**

(*ii*) State the principle of conservation of energy.

energy cannot be created or destroyed **[6]**

[accept partial answer for 3]

(*iii*) What is the main type of energy that the stone's kinetic energy is being converted into as it travels upwards?

potential energy **[6]**

[accept partial answer for 3]

(*iv*) Calculate the kinetic energy of the stone when it is thrown.

$\frac{1}{2} \times 0.005 \times 15^2 = 0.5625$ J **[5]**

[accept partial answer for 3]

(*v*) Calculate the maximum height reached by the stone.

$0.5625 \div (0.005 \times 9.8) = 11.5$ m // $15^2 \div (2 \times 9.8) = 11.5$ m **[5]**

[accept partial answer for 3]

(*vi*) What is the unit of energy?

Joule / J **[3]**

(*acceleration due to gravity = 9.8 m s^{-2}*)

(*b*) In order for an observer to see a mirage on a hot day, total internal reflection must occur. Mirages happen when the ground is very hot and the hot air just above the ground and the cool air higher up have different refractive indices. Light undergoes refraction as it travels from the cool air into the hot air.

(*i*) Describe an experiment to demonstrate total internal reflection.

apparatus 1, e.g. ray box / laser **[3]**

apparatus 2, 3.g. semi-circular glass block **[3]**

method **[3]**

observation **[3]**

To see an object clearly, light from an object must enter the eye through the pupil and come to focus on the retina at the back of the eye. The eye focusses the light onto the retina.

(*ii*) If the light from a distant object comes to focus in front of the retina, the person will see a blurred image. This person is said to be short sighted.
What type of lens is used to correct short sightedness?

concave / diverging **[6]**

[accept partial answer for 3]

(*iii*) A certain person's eye has a power of 62 m^{-1}.
The lens of their glasses has a power of –2 m^{-1}.

(*a*) Calculate the power of the combination of the eye and the lens.

$\boldsymbol{P = 62 + (-2) = 60\ m^{-1}}$ **[5]**

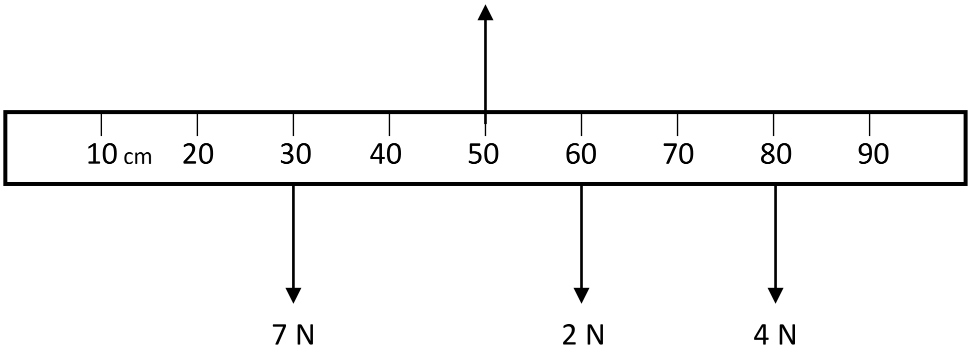
[accept partial answer for 3]

(*b*) Calculate the focal length of the lens in the glasses.

$\boldsymbol{f = 1 \div 2 = 0.5\ m}$ **[5]**

[accept partial answer for 3]

(*c*) The diagram shows a metre stick which is suspended from its mid-point (50 cm) with three masses hanging from it. The metre stick is in equilibrium.



(*i*) A moment is a turning effect caused by a force. The 2 N force and the 4 N force result in clockwise moments about the midpoint of the metre stick. Calculate the total clockwise moment about the midpoint of the metre stick.

(2 × 0.1) + (4 × 0.3) = 1.4 N m **[6]**

[accept partial answer for 3]

(*ii*) The 7 N force results in an anticlockwise moment about the midpoint of the metre stick. Calculate the total anticlockwise moment about the midpoint of the metre stick.

7 × 0.2 = 1.4 N m **[6]**

[accept partial answer for 3]

(*iii*) State the law of equilibrium verified by the calculations in (*i*) and (*ii*).

clockwise moments = anti-clockwise moments **[6]**

[accept partial answer for 3]

(*iv*) The upward force on the metre stick is 15 N. Calculate the weight of the metre stick.

15 – (7 + 2 + 4) = 2 N **[6]**

[accept partial answer for 3]

(*v*) Your calculations assume that the centre of gravity of the metre stick acts at the mid-point of the metre stick. What might cause this assumption to be invalid?

e.g. chipped metre stick etc. **[4]**

[accept partial answer for 2]

(*d*) Henri Becquerel was the first person to discover evidence of radioactivity. Radioactivity is the emission of radiation as a result of the decay of atomic nuclei.

(*i*) Alpha radiation is one of the three types of radiation. Name the other two types of radiation.

beta/β **[3]**

gamma/γ **[3]**

(*ii*) Alpha radiation is the least penetrating of the three types of radiation. Describe an experiment to show that the three types of radiation have different penetrating powers.

apparatus 1: source of radiation **[3]**

apparatus 2: barrier[s] **[3]**

method **[3]**

observation / detector **[3]**

Radium (Ra_{88}^{226}) is an alpha emitter.

(*iii*) How many neutrons are there in an atom of Ra_{88}^{226}?

226 – 88 = 138 **[6]**

[accept partial answer for 3, e.g. number of protons]

(*iv*) What is the daughter nucleus when an atom of Ra_{88}^{226} emits two alpha particles?

Po_{84}^{218} **[2 + 1 + 1]**

[accept partial answer for 2]