Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2022

Marking Scheme

Physics and Chemistry

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.

Coimisiún na Scrúduithe Stáit
State Examinations Commission

LEAVING CERTIFICATE EXAMINATION

PHYSICS AND CHEMISTRY – ORDINARY LEVEL

General Guidelines

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

1. In many instances only key words are given, i.e. 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. Where indicated, 1 mark is deducted for incorrect/no units.

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

8. Cancellation may apply when a candidate gives a list of correct and incorrect answers.

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

10. 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 less than 75% of the total marks. 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. The bonus table given on the next page applies to candidates who answer entirely through Irish and who obtained more than 75% of the total marks.

Coimisiún na Scrúduithe Stáit

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 330 @ 10%

Bain úsáid as an tábla seo i gcás na n-ábhar a bhfuil 330 marc san iomlán ag gabháil leo agus inarb é 10% gnáthráta an bhónais.
Bain úsáid as an ngnáthráta i gcás 247 marc agus faoina bhun sin. Os cionn an mharc sin, féach an tábla thíos.

Bunmharc	Marc Bónais
248 - 250	24
251 - 253	23
254 - 256	22
257 - 260	21
261 - 263	20
264 - 266	19
267 - 270	18
271 - 273	17
274 - 276	16
277 - 280	15
281 - 283	14
284 - 286	13
287 - 290	12

Bunmharc	Marc Bónais
291 - 293	11
294 - 296	10
297 - 300	9
301 - 303	8
304 - 306	7
307 - 310	6
311 - 313	5
314 - 316	4
317 - 320	3
321 - 323	2
324 - 326	1
327 - 330	0

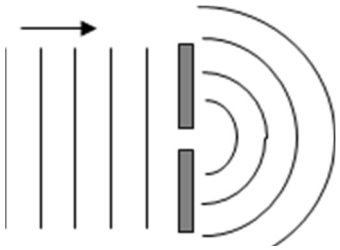
Question 1
Any eleven parts **11×6**

(*a*) What is meant by potential energy? **5, 1 or 6**
energy due to // energy of a // energy
position or condition // body at a height // stored
first correct …5, second correct …1
or
mgh …6
[Example …4]

(*b*) How long does it take a swimmer, moving at a constant speed of 1.5 m s^{-1}, to swim 50 m? **5, 1**
$s = vt$ / $t = s \div v$ …5
(t =) 33.3 (s) …1

(*c*) Figure 1 shows a 3 kg kettlebell. Calculate the weight of the kettlebell. [acceleration due to gravity, g = 9.8 m s^{-2}] **5, 1**
(W =) mg / (W =) 3 × 9.8 …5
(W =) 29.4 (N) …1

(*d*) Sketch a diagram to show diffraction of plane waves after passing through a narrow gap. **5, 1**
waves shown approaching gap
spreading of waves after gap



first correct ...5, second correct ...1

***(e)* How would you show that white light is composed of a mixture of colours?** **6**
prism / spectrum / rainbow / diffraction grating, etc …6

***(f)* Give one use for a concave mirror.** **6**
produce a magnified image / in dentistry / for shaving / for make-up application / reflector in lamp / etc …6
[Use for convex mirror or concave lens ….3]

(*g*) Figure 2 shows a waveform. What term is given to the distance marked X? **6**
wavelength …6

(*h*) What is meant by Brownian motion? **5, 1**
movement or motion or activity of (small) particles / zig-zag or random (motion) of (small) particles …5
(suspended) in a liquid or a gas …1
[Allow an example …5]

(*i*) State one assumption of the kinetic theory of gases. **6**

(large number of) particles or molecules / rapid motion / random motion / straight line motion / collisions occur between particles or molecules / collisions occur with walls of container / collisions elastic or involve neither loss nor gain of energy / negligible volume occupied by particles or molecules / negligible duration of collisions / no forces (between particles except during collisions), etc …6

(*j*) Identify the gas law that states that the product of pressure and volume (*pV*) of a fixed mass of gas is constant at a particular temperature. **6**

Boyle …6

[Alllow …3 for Charles]

(*k*) Convert 4.7 kiloohms (kΩ) to ohms (Ω). **6**

4700 …6

[Allow 0.0047 …3]

(*l*) Copy and complete the following statement of *Coulomb's law*:

"The force between two point charges is proportional to the . . . . . of the charges and inversely proportional to the square of the . . . . . between them." **5, 1**

size / magnitude / product

distance / separation

first correct …5, second correct …1

[Formula …3]

(*m*) Calculate the effective capacitance of a *parallel* arrangement of two 6 μF capacitors. **5, 1**

$C_1 + C_2 = C$ …5

(C = 6 + 6 =) 12 (μF) …1

[Allow 1.5 (μF) …3 or 0.67 or (μF) ...2]

(*n*) What is meant by the *photoelectric effect*? **5, 1**

release of electrons from (surface of) a metal

illuminated by electromagnetic radiation or light (above a certain frequency)

first correct …5, second correct …1

(*o*) Figure 3 shows a bar magnet.

Copy the diagram and sketch the magnetic field linesaround the bar magnet. **5, 1**

field lines …5

direction of field lines …1

Figure 3

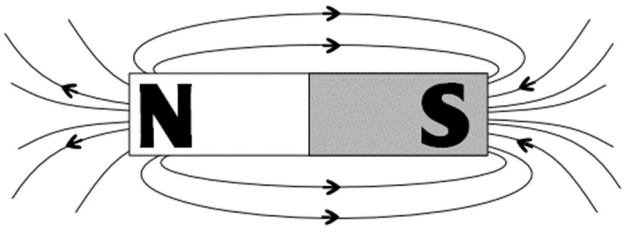


Figure 3 completed

(*p*) Identify one method of detecting nuclear radiation. **6**

photographic film / Geiger-Müller device / cloud chamber / electroscope / scintillations / ionisation / solid state detector / etc …6

(*q*) Iodine-131 has a half-life of 8 days.

What fraction of a sample of iodine–131 remains after 16 days? **5, 1**

(16 days =) 2 half-lives …5

¼ …1

[Allow 25% ….6][Allow $T_{1/2} = \frac{ln2}{\lambda}$ ....5]

(*r*) State Einstein's equation which relates energy and mass. **5, 1**

$E = mc^2$

first correct …5, second correct …1

Question 2

(*a*) (i) Define acceleration. **5, 1**

rate of change or change over time // $v - u$
of velocity or of speed in a given direction // $\div t$
[change of speed or getting faster ….3]

first correct …5, second correct …1

(ii) What is the S.I. unit of acceleration? **6**

m s^{-2} …6
[Allow …3 for m s^{-1}]

(iii) Define kinetic energy. **5, 1 or 6**

energy of a // energy due to
moving object // motion

first correct …5, second correct …1

or
$\frac{1}{2}mv^2$ …6
[Example …4]

(*b*) Figure 4 shows a hippopotamus and her calf. The adult hippopotamus of mass 1,400 kg reached a velocity of 8 m s^{-1} starting from rest and accelerating uniformly for 5 seconds.

Calculate

(i) the acceleration of the adult hippopotamus **5, 1**

$a = \frac{v-u}{t}$ / $v = u + at$ …5
($a = \frac{8-0}{5}$ =) 1.6 (m s^{-2}) …1

(ii) the distance covered by the adult hippopotamus in the 5 seconds **5, 1**

$s = ut + \frac{1}{2}at^2$ / $s = \frac{1}{2}at^2$ / s = ½ × 1.6 × 5^2 // $s = \frac{1}{2}(u + v)\,t$ / $s = \frac{1}{2}(0+8) \times 5$ //
$v^2 = u^2 + 2as$ / $5^2 = 0^2 + 2(1.6)s$ …5
$\Rightarrow$ (s =) 20 m …1
[no unit or incorrect unit (–1)]

(iii) the time taken by the hippopotamus to move the first 10 metres **5, 1**

$s = ut + \frac{1}{2}at^2$ / $s = \frac{1}{2}at^2$ / 10 = ½ × 1.6 × t^2 …5
$\Rightarrow$ (t =) 3.5 s …1
[no unit or incorrect unit (–1)]

(iv) the maximum kinetic energy of the adult hippopotamus. **5, 1**

(E =) $\frac{1}{2}mv^2$ / (E =) ½(1400) × 8^2 …5
(E =) 44800 (J) or 44.8 (kJ) …1

Why did the kinetic energy of the hippopotamus increase over the 5 seconds? **6**

speed or velocity increasing / accelerating / moved from rest …6

(*c*) The hippopotamus calf of mass 180 kg accelerated uniformly as a result of its muscles producing a force of 220 N.

(i) What was the acceleration of the calf? **5, 3, 1**

(F =) ma …5

220 = 180 × a …3

(a =) 1.2 (m s^{-2}) …1

(ii) Did these two animals have the same kinetic energy when they had the same speed? **3**

no …3

Give a reason for your answer. **6**

different masses / different sizes …6

Question 3

(*a*) Figure 5 shows a pair of convex lenses in reading glasses being used to magnify text.
Reading glasses are an application of the refraction of light.
What is meant by the underlined term? **5, 1**

bending (of light)
as it passes from one medium to another
[Reflection instead of refraction …3]

first correct …5, second correct …1

State the laws of refraction of light. **2×3, 6**

$\frac{sini}{sinr}$ …3
= constant / = *k* or *n* or μ or constant …3

or

sine of angle of incidence proportional to // sin*i* is proportional to …3
sine angle of refraction // sin*r* …3
[reflection instead of refraction …(–1) [sines omitted (–3)]

and

the incident ray or beam, the refracted ray or beam and the normal in the same plane …6
[normal omitted (–1)][reflection instead of refraction (–1) but once only for both laws]
[reference two only of incident ray, refracted ray and normal …(–1)]

(*b*) Figure 6 shows light rays from a *distant* object emerging from a convex lens.
Redraw the diagram showing the rays as they *approach* the lens. **5, 1**

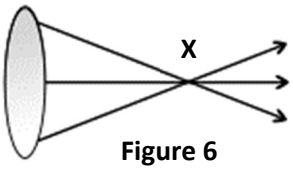


Figure 6

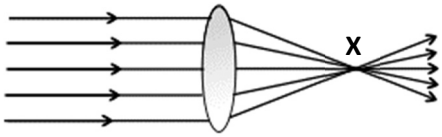


Figure 6 completed

rays approach lens …5
parallel …1

What term describes the point labelled X? **6**
focus / focal point / *F* …6

Describe a laboratory experiment to find the distance from X to the lens. **3×3**
pin or ray box or distant object, screen or sheet of paper, (lens) …3
image of distant object on screen or paper // object distance and image distance …3
measure distance from screen or paper to lens // use formula or graph to find focal length …3

(*c*) Copy and complete Figure 7 to show how a convex lens can form a magnified image. **2×3**

any refracted ray from object …3

image formation …3

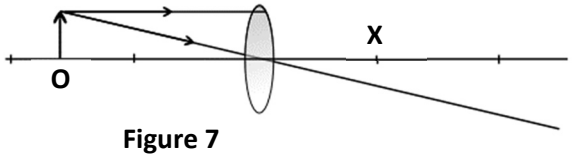


Figure 7

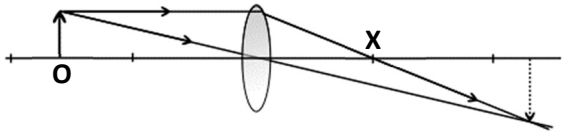


Figure 7 completed

Give one difference between this image and the type of image formed when using reading glasses. **9**

inverted or upside down / object and image on opposite sides of lens / real …9

[Allow reading glasses give upright image or image on same side of lens as object or virtual image …9]

[Allow reading glasses give magnified image …6]

(*d*) Figure 8 shows a ray of light entering a triangular glass prism and travelling through it.

(i) State the angle of incidence at A, **6**

0° …6

[Allow 90° …3]

(ii) What phenomenon occurs at B and at C? **2×3**

total internal …3

reflection …3

Question 4

Figure 9 shows two liquid-in-glass thermometers, a traditional clinical mercury thermometer and an alcohol-based laboratory thermometer.

(*a*) The clinical thermometer measured a person's body temperature as 37 °C.
What is this temperature on the Kelvin scale? **6**
37+ 273(.15) = 310(.15) (°C) …6
[reference to 273(.15) …5]

Give one disadvantage of using mercury in a thermometer. **6**
mercury toxic or poisonous or harmful / not very sensitive / not very accurate / expensive …6

(*b*) What is meant by a thermometric property? **2×3**
(physical) property …3
that varies (measurably) with temperature …3
[heat instead of temperature (–1)]

What is the thermometric property on which all liquid-in-glass thermometers are based? **9**
height or volume or length (of liquid) …9

Give one example of a thermometer which uses a different thermometric property. **6, 3**
constant pressure gas thermometer, constant volume gas thermometer, platinum resistance thermometer, thermocouple, etc

State the thermometric property on which your example is based.
corresponding thermometric property: volume, pressure, resistance, emf, etc
first correct …6, second correct …3

(*c*) State the temperatures on the Celsius scale assigned to the fixed points
(i) melting ice **9, 9, 6**
0
[Allow …6 for 273]

(ii) the steam above boiling water.
100
[Allow …6 for 373]
[Take order of question unless answers labelled]

A student noted that the length of the liquid inside a liquid-in-glass thermometer was 2.0 cm in an ice-water mixture and 10.2 cm in the steam above boiling water.
What is the difference in the length of liquid between the two fixed points?
8.2 cm / 8 cm
[no unit or incorrect unit (–1)]
first correct …9, second correct …9, third correct …6

Calculate the length of the liquid when this thermometer reads 37 °C. **5, 1**
$(t =) \frac{x_t - x_0}{x_{100} - x_0} \times 100$ // 8.2 ÷ 100 = 0.082 …5
$37 = \frac{h - 2.0}{10.2 - 2.0} \times 100 \Rightarrow$ (*h* =) 5.0(34) cm // 0.082 × 37 = 3 .034 $\Rightarrow$ (*h* = 2.0 + 3.034 =) 5.0(34) cm …1
[no unit or incorrect unit (–1)]

Question 5

(*a*) Figure 10 shows a miniature circuit breaker (mcb) and a fuse, two safety devices commonly used in household electrical circuits. The mcb uses the magnetic effect of a current.

Give two other effects of an electric current. **6, 3**

heat / heating

chemical

first correct …6, second correct …3

How does the fuse work as an electrical safety device? **5, 1**

melts / breaks // uses heating effect of electricity …5

when current is too big // to break circuit ...1

(*b*) The table below records the electrical energy consumption of a water heater over a one-hour period.

Energy (kW h)	0	0.4	0.8	1.2	1.8	2.4
Time (minutes)	0	10	20	30	45	60

Draw a graph on graph paper of energy (*y*-axis) against time (*x*-axis). **5×3**

x-axis labelled time or *t* or minutes …3

y-axis labelled energy or kW h

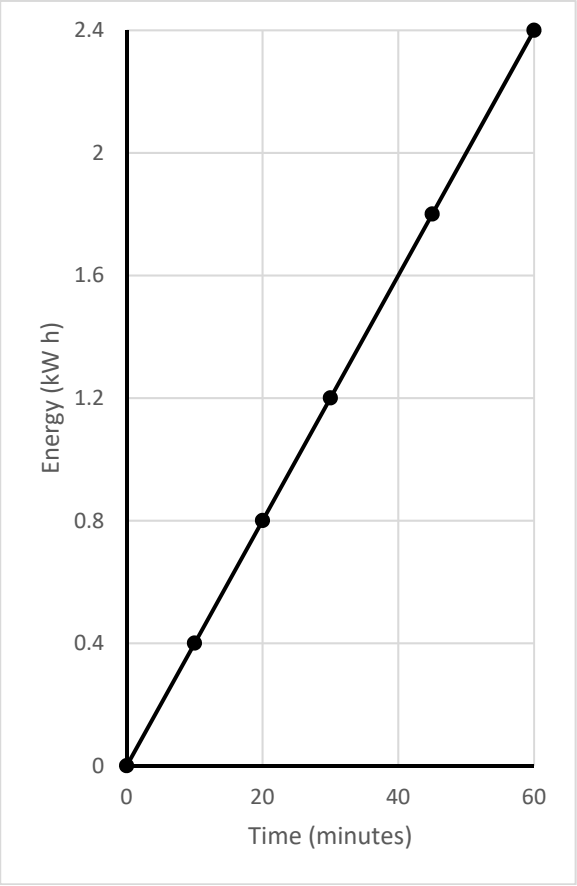
axes drawn with appropriate scales …3

six points plotted correctly …3

points joined by a straight line …3

[Allow 9 (max) if graph paper not used.] ...3

[No penalty if axes reversed].



How much electrical energy was consumed every 15 minutes? **3**

0.6 kW h / 600 W h / 2.16×10^6 J …3

[Allow …3 for correct use of graph at 15 minutes without giving numerical reading from energy axis]

[no unit or incorrect unit (–1)]

(*c*) Figure 11 shows a 6 Ω resistor and a 2 Ω resistor connected in series with a battery. The ammeter in the circuit gives a reading of 3.0 A when the switch was closed.

(i) Explain why the reading would also be at 3.0 A if the ammeter was placed between the two resistors. **6**

current same throughout circuit / same current flows / series circuit, etc …6

(ii) State Ohm's law. **3×3**

current (in a conductor) // potential difference …3

at constant temperature is proportional to …3

potential difference // current (in a conductor) …3

[constant temperature omitted (–1)]

[Allow $V = IR$...(–1)]

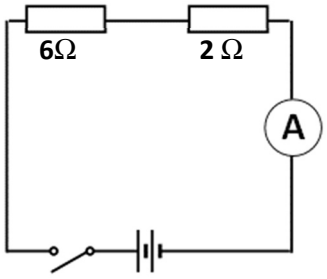


Figure 11

Calculate

(iii) the effective resistance of the two resistors **5, 1**

$R = R_1 + R_2$ / $R = 6 + 2$ …5

($\Rightarrow R =$) 8 (Ω) …1

[parallel here instead of series …3 max]

(iv) the voltage (potential difference) across the 6 Ω resistor **5, 1**

$V = IR$ / $I = \frac{V}{R}$ / ratio of voltages 3:1 …5

($\Rightarrow V = 6 \times 3 =$) 18 V* / (¾ of 24 V =) 18 V* …1

[*no unit or incorrect unit (–1) but once only in (iv) and (v)]

(v) the voltage of the battery in the circuit. **5, 1**

$V = IR$ / $I = \frac{V}{R}$ …5

($\Rightarrow V = 8 \times 3 =$) 24 V* …1

[*no unit or incorrect unit (–1) but once only in (iv) and (v)]]

Question 6
Answer any two parts. **2×33**

(*a*) State the principle of conservation of momentum. **4, 4, 1**
(total) momentum before (a collision) equals // (total) momentum remains or is // $m_1u_1 + m_2u_2 =$ …4
momentum after // constant // $m_1v_1 + m_2v_2$ or $(m_1 + m_2)v$ …4
when no external force acts or in a closed system …1
[rate of change of momentum proportional to applied force, allow …6]
[principle of conservation of energy, allow …(6)]

Figure 12 shows two skateboards each of mass 5.2 kg on a smooth horizontal surface. Skateboard A moving at 0.85 m s^{-1} collides with skateboard B which is at rest. Both skateboards move in the same direction After the collision and the speed of skateboard A is now 0.37 m s^{-1}.

Calculate
(i) the momentum of skateboard A *before* the collision **5, 1**
mv or *mu* / 5.2 × 0.85 …5
(*mv* or *mu* =) 4.42 kg m s^{-1} (to the right)* …1
[*no unit or incorrect unit (–1) but once only in calculate]

(ii) the momentum of skateboard A *after* the collision **5, 1**
mv or *mu* / 5.2 × 0.37 …5
(*mv* or *mu* =) 1.924 kg m s^{-1} (to the right)* …1
[*no unit or incorrect unit (–1) but once only in calculate]

(iii) the momentum of skateboard B *after* the collision **5, 1**
$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ / 1.924 + (5.2 × 0) = 2.496 + m_2v_2 …5
(m_2v_2 =) 4.42 – 1.924 = 2.496 kg m s^{-1} (to the right)* …1
[*no unit or incorrect unit (–1) but once only in calculate]

(iv) the speed of skateboard B *after* the collision. **5, 1**
(v_2 =) $\frac{2.496}{5.2}$ / (v_2 =) 0.85 – 0.37 …5
(v_2 =) 0.48 m s^{-1} (to the right) …1
[no unit or incorrect unit (–1)]

(*b*) Figure 13 shows party balloons that are filled with helium gas. All the helium gas on Earth was formed from alpha particles released during radioactive decay of some unstable nuclei.

In terms of subatomic particles, what is the composition of an alpha particle? **2×3**
two protons // helium …3
two neutrons // nucleus …3
[Allow He_2^4 …6]

How many electrons must an alpha particle gain to form an atom of helium? **6**
2 / two …6

Give one way to change the direction of a stream of moving alpha particles. **6**
electrical field / magnetic field / hit it with another particle / charged particle or
any named charged particle (nearby) …6

State a precaution to be taken when handling a source of alpha particles. **3**
handle with tongs / use shielding or protective clothing / do not ingest / do not eat or drink or smoke or apply make-up near radioactive materials / wear dosage indicator / etc …3

Identify two other types of radiation released during radioactive decay of unstable nuclei. **9, 3**
beta or β (particle)
gamma or γ (radiation)
first correct …9, second correct …3

[Allow any other radiation, e.g. x-ray …6]

(*c*) Consider the descriptions in the table about electromagnetic induction.

A	**S.I. unit named after the scientist who discovered electromagnetic induction**
B	**A device that uses electromagnetic induction to change the size of an alternating voltage**
C	**Type of current in a wire that gives rise to a steady magnetic field**
D	**Type of charge on a subatomic particle carrying a current in a metallic conductor**
E	**S.I. unit used to measure the size of an induced voltage**
F	**A device that converts mechanical energy into electrical energy**
G	**Type of current which is detected by the oscillation of a galvanometer needle**

In your answerbook match each term below with its description (A, B, C, D, E, F or G) in the table.

alternating direct dynamo farad
negative transformer volt **10, 6, 5×1**

A	farad		alternating	G
B	transformer		direct	C
C	direct		dynamo	F
D	negative		farad	A
E	volt		negative	D
F	dynamo		transformer	B
G	alternating		volt	E

first correct …10, second correct …6, others correct …5×1

Describe how you could demonstrate electromagnetic induction. **2×5, 2×1**

coil and galvanometer …5
magnet // alternating current supply …5
relative motion between coil and magnet // coil and alternating supply in second coil …1
observe galvanometer deflection …1
[Marks may be awarded for information given in a diagram.]

(*d*) Draw a labelled diagram of a gold leaf electroscope. **2×6**

cap, rod, case …6

leaf or leaves shown …6

[No labels …(–1)]

How would you use a negatively charged electroscope to determine if a charged plastic rod was also negatively charged? **5, 1**

bring rod near cap …5

leaves diverge rod negative / leaves collapse rod (probably) positive …1

Figure 14 shows a positively charged rod held near two neutral conducting spheres on insulated stands. The spheres are touching.
Sphere Y was moved to the right and the rod was then removed.
State the net charge now on sphere X. **6**

negative …6

Explain your answer. **3**

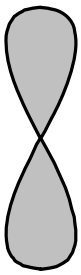
electrons or negative charges attracted left by positively charged rod /
electrons or negative charges from Y remain in X when the spheres are separated …3

State the net charge on sphere Y after it is earthed. **6**

zero / 0 …6

Question 7

Any eleven parts **11×6**



(*a*) Sketch the shape of a *p*-orbital. **6**
dumbbell drawn …6
[Allow dumbell in words or sphere in words or drawing of sphere …3]

(*b*) Figure 15 represents graphene, an allotrope of the element carbon.
What are allotropes? **2×3**
(different physical) forms …3
of same element …3

(*c*) Select two noble gases from the following:
hydrogen helium nitrogen oxygen argon **5, 1**
argon
helium
first correct…5, second correct...1

(*d*) What is meant by a standard solution? **6**
has known concentration …6

(*e*) Give one property characteristic of transition metal compounds. **6**
coloured compounds / good catalysts …6
[property of transition element …3][property of metal …3]

(*f*) Calculate the percentage by mass of magnesium in magnesium nitride (Mg_3N_2).
[N = 14; Mg = 24] **5, 1**
(M_r = (24 × 3) + (14 × 2)) = 100 ...5
$\frac{72}{100} \times 100 = 72(\%)$ …1

(*g*) Arrange the following metals in order of *increasing* ease of oxidation:
aluminium sodium zinc **6**
zinc, aluminium, sodium …6
[reversed …3]

(*h*) Give one property characteristic of metallic crystals. **6**
conduct electricity / conduct heat / malleable / ductile / hard, etc any one…. 6

(*i*) Identify the type of bond *between* water molecules represented by the broken lines in Figure 16. **6**
hydrogen or H (bond) / intermolecular (force) / dipole-dipole (interaction) …6
[Allow van der Waals (force)]

(*j*) Define reduction in terms of electron transfer. **2×3**
gain …3
of electrons …3

(*k*) Copy, complete and balance the following equation:

Na_2SO_3 + HCl → NaCl + _____ + H_2O **4, 2**

$Na_2SO_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O$

SO_2 …4

balanced …2

(*l*) State Hess's law. **2×3**

heat change for a reaction …3

depends only on initial and final states / is independent of path followed / is the same whether reaction occurs in one or several stages …3

(*m*) What is meant by an *endothermic* reaction? **6**

heat or energy …3

taken in …3

[Allow exothermic reaction …3]

(*n*) Give an example of

(i) an acidic oxide. **5, 1**

CO_2 / SO_2 / SO_3 / NO_2 or N_2O_4 or N_2O_5, etc

(ii) a basic oxide,

CaO / MgO / Na_2O or Na_2O_2, etc

[Names of oxides acceptable]

first correct …5, second correct …1

(*o*) How many atoms, and of which element, are removed when a molecule of ethanol (C_2H_5OH) is oxidised to a molecule of ethanal (CH_3CHO)? **2×3**

2 …3

H or hydrogen …3

(*p*) Identify the functional group in a ketone. **6**

carbonyl (group) / C=O …6

[Allow CO…3]

(*q*) Why are the compounds whose structures are shown in Figure 17 both classified as aromatic alcohols? **5, 1**

(both have a) benzene ring

(both have an) OH or hydroxyl (group)

first correct…5, second correct...1

(*r*) What two organic compounds react to form the ester ethyl ethanoate ($CH_3COOC_2H_5$)? **5, 1**

ethanol or C_2H_5OH /

ethanoic acid or CH_3COOH

first correct…5, second correct...1

Question 8

(*a*) $^{35}_{17}\mathbf{Cl}$ **is the most abundant of the isotopes of the element chlorine.**

Explain the underlined terms. **2×3 and 5, 1 or 6**

isotopes:

atoms with same atomic number or same number of protons …3

different numbers of neutrons / different mass number …3

element:

cannot be broken down (chemically) …5

into simpler substance(s) …1

or

(composed only of) atoms with same number of protons or same atomic number /
(composed of only) one type of atom …6

[Allow …5 for substance listed on periodic table]

State the number of (i) protons, (ii) neutrons, found in an atom of this isotope. **9, 3**

17

18

first correct…9, second correct...3

Write the electron configuration (*s*, *p*) for an atom of chlorine. **2×3**

Is^2 2$s^2$2p^6 / [Ne] …3

3$s^2$3p^5 / 3s^2 3$p_x^2$3$p_y^2$3p_z^1 …3

[Allow 2,8, 7 …5]

(*b*) Define *electronegativity*. **5, 1**

relative attraction / measure of power of attraction or measure of force of attraction
for electrons in a shared pair or in a covalent bond

[relative or measure of omitted … (–1)]

first correct …5, second correct …1

Use electronegativity values (on page 81 of the *Formulae and Tables* booklet) to predict the type of chemical bonding found in hydrogen bromide (HBr). **6**

polar / polar covalent …6

[Allow covalent …5]

[Electronegativity values of H and Br …4 if no other marks awarded]

Copy Figure 18, that represents a single molecule of HBr, into your answerbook and mark clearly on your diagram

(i) a partial negative charge **6**

bromine indicated as (partially) negative …6

(ii) a partial positive charge. **6**

hydrogen indicated as (partially) positive …6

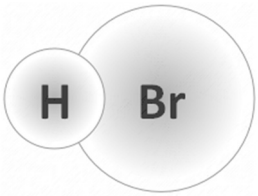


Figure 18

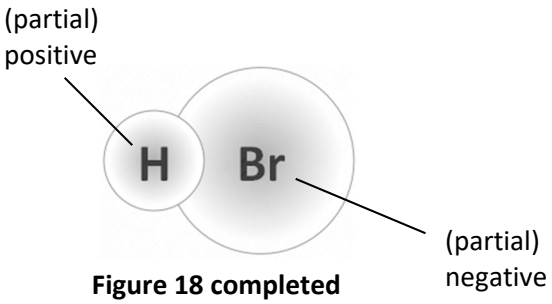


Figure 18 completed

[charges reversed …6]

(iii) Would you expect HBr to be soluble in water? **3**

yes …3

Explain your answer. **3**

polar / attraction between partial charges of HBr and water / dipole moment / like dissolves like …3

(iv) Would you expect HBr to be a crystalline solid with a high melting point? **3**

no

Explain your answer. **3**

electronegativity difference too small / polar or covalent / not ionic, etc …3

Question 9

Hydrogen produced by the electrolysis of acidified water is called 'green hydrogen' if renewable electricity is used, e.g. electricity generated from wind turbines similar to those in Figure 19 located in Drumkeeran, County Leitrim.

Figure 20 shows apparatus used to electrolyse acidified water in the laboratory.

Name an unreactive material suitable for use as the electrodes X and Y. **9, 6, 3, 3**

graphite or carbon / platinum

At which electrode does oxidation occur?

anode / left hand side / X

What gas is collected at (i) A,

oxygen / O_2

[O (–1)]

(ii) B?

hydrogen / H_2

[H (–1)]

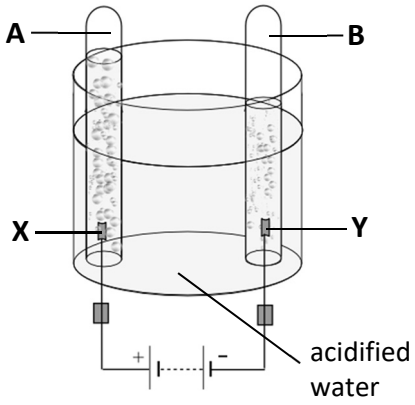


Figure 20

first correct …9, second correct …6, third correct ……3, fourth correct 3

[If (i) and (ii) reversed (–3)]

Describe a test to confirm the identity of the gas at B. **6**

burns with a pop …6

[reignites flame or other test if reversed or incorrect above …6]

Give one commercial use for this gas. **6**

fuel / heating / reducing agent / to make ammonia / hydrogenation of fats and oils, etc …6

[Accept use of oxygen, e.g. breathing or other gas if gas reversed or incorrect above …6]

(*b*) State the Brønsted-Lowry definition of (i) an acid, **2×3**

proton / H^+ …3

donor …3

[Allow acid produces hydrogen or H^+ or hydronium or H_3O^+ (in solution) ...5]

(ii) a base. **2×3**

proton / H^+ …3

acceptor …3

[Allow base produces hydroxide ions or OH^-(in solution) ...5]

What is meant by a *weak acid*? **2×3**

poor //not fully or slightly or partly …3

proton donor // dissociated …3

Identify two acids in the following equation:

$NH_3 + H_2S \rightleftharpoons NH_4^+ + HS^-$ **2, 1**

H_2S
NH_4^+

first correct …2, second correct …1

What information does the pH value of a solution give about it? **6**

how acidic or basic it is / whether it's an acid or a base (or neutral) /
(measure of) H^+ or OH^- concentration / $-\log[H^+]$ …6

Calculate the pH of a 0.039 M solution of nitric acid (HNO_3). **5, 1**

$pH = -\log[H^+]$ ...5
$pH = -\log[0.039] = 1.4 - 1.41$ ...1

Question 10

Some glassware used to titrate a solution of sodium hydroxide (NaOH) with a hydrochloric acid (HCl) solution, and then separate the salt NaCl from the neutralised solution, is shown in Figure 21.
The balanced equation for the titration reaction is:

HCl + NaOH → NaCl + H_2O

(*a*) (i) Name two pieces of personal protective equipment (PPE) worn when using chemicals in a laboratory. **2×6**

goggles or eye protection / gloves / hair-tie / lab-coat or apron

any two…2×6

(ii) Identify A and B. **2×6**

A: pipette …6
B: burette …6
[reversed …6]

(iii) Describe how A is prepared for use in this titration. **2×3**

rinse with deionised or distilled water …3
rinse with NaOH or sodium hydroxide or solution it will contain …3
[rinsings reversed …3]

(iv) Give one precaution to ensure accuracy when taking a reading from B. **6**

read at eye level / read bottom of meniscus / use contrast to see scale (of B) / ensure (B) vertical …6
[Allow repeat]

(*b*) When carrying out a number of titrations of the NaOH with the HCl a few drops of substance X were added to conical flask C containing the base but X was omitted from the final titration.

(i) Name a suitable substance for use as X. **3**

any named acid base indicator, e.g. methyl orange, phenolphthalein, etc …3

(ii) What is the purpose of adding X? **3**

as an indicator / so a (colour) change can be seen /
to show when neutralisation occurs or when enough HCl added …3

(iii) Suggest a reason why X was omitted from the final titration. **3**

to avoid contaminating or colouring salt /
volume of HCl known /
not needed ...3

(iv) Find the concentration of the sodium hydroxide solution used if 25.0 cm³ portions of it required, on average, 22.9 cm³ of 1.13 M HCl for neutralisation. **6, 2, 1**

$\frac{V_1 M_1}{n_1} = \frac{V_2 M_2}{n_2}$ …6

$\frac{\mathbf{22.9 \times 1.13}}{\mathbf{1}} = \frac{\mathbf{25.0 \times M_2}}{\mathbf{1}}$ …2

(M_2 =) 1.035 – 1.04 (mole/l) NaOH …1

[correct formula, incorrect substitution …6 max]

or

moles of HCl used = $\frac{22.9 \times 1.13}{1000}$ …6

(moles HCl used) = 0.025877 …2

0.025877 moles of NOH in 25.0 cm³ $\Rightarrow \frac{0.025877 \times 1000}{25.0}$ = 1.035 (moles /L) [1.035 – 1.04 M] …1

(*c*) (i) What process occurs in D that separates the salt from the neutralised solution? **9, 3**

evaporation or boiling /crystallisation

(ii) Give a common use for the salt NaCl.

flavouring, preserving, de-icing (roads), saline solutions or drips, etc

first correct…9, second correct...3

Question 11

The space heater shown in Figure 23 is fuelled by propane (C_3H_8) contained in a cylinder in its base. Propane is the third member of a homologous series of <u>hydrocarbons</u>.

(*a*) (i) Explain the underlined term. **<u>9, 6, 3</u>**

compound of carbon or C and hydrogen or H (only)

(ii) Name the homologous series to which propane belongs.

alkanes

(iii) Give the name of the first member of this homologous series.

methane

first correct…9, second correct...6, third correct …3

(iv) Give two physical properties of these members of this homologous series. **<u>6, 3</u>**

colourless /
odourless /
insoluble in water /
(lower members) gaseous /
low boiling points /
flammable

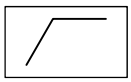
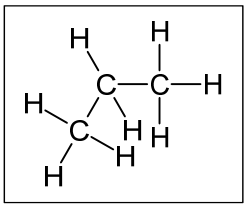
first correct…6, second correct…3

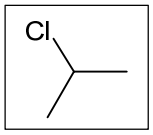
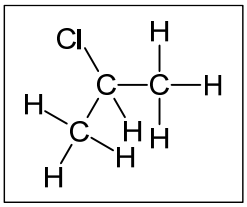
(*b*) (i) Why is propane described as a *saturated* hydrocarbon? **<u>6</u>**

contains no double (or triple) bond or contains no multiple (carbon-carbon) bond /
cannot add hydrogen / has single (carbon-carbon) bonds …6

Propane is converted to 2-chloropropane when it reacts with Cl_2.

(ii) Draw the structures of the propane and 2-chloropropane molecules. **<u>9, 3</u>**

$CH_3CH_2CH_3$ or  or 

$CH_3CHClCH_3$  or 

[Hs need not be shown explicitly]

first correct…9, second correct…3

(iii) Is the conversion of propane to 2-chloropropane an addition, an elimination, or a substitution reaction? **<u>3</u>**

substitution …3

(*c*) Propane burns according to the following balanced equation:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O \qquad \Delta H = -2{,}219 \text{ kJ mol}^{-1}$$

When 5 moles of propane are completely burned, calculate

(i) the quantity of energy released **6, 3**

(1 mole releases) 2,219 …6

$2{,}219 \times 5 = 11{,}095$ (kJ mol^{-1}) …3

[Ignore negative sign if given]

(ii) the number of moles of carbon dioxide produced. **6, 3**

(1 mole propane produces) 3 (moles CO_2) …6

$3 \times 5 = 15$ (moles) …3

Question 12
Answer any two parts. **2×33**

(*a*) Figure 23 shows a laboratory preparation of oxygen gas by the decomposition of a certain liquid and
to collect test-tubes of the gas formed.
(i) Identify liquid A and solid B. **9, 2×3**
A: hydrogen peroxide or H_2O_2 (solution)
B: manganese dioxide or MnO_2 or liver, celery, etc

(ii) What is the purpose of B?
catalyst / speeds up decomposition or reaction of (hydrogen peroxide)
first correct…9, second correct...3, third correct …3

(iii) Describe how a glowing wooden splint could be used to confirm the presence of oxygen in one of the test-tubes of gas collected. **9, 6, 3**
glowing splint relights (is confirmation of oxygen)
[burns in oxygen …3]

(iv) What compound is produced if a sample of magnesium metal is burned in oxygen?
MgO or magnesium oxide

(v) Give one commercial use for oxygen gas.
steel-making / rocket fuel oxidant / oxyacetylene flame / welding or cutting metals / supports fuel combustion / combat pollution in water / beauty (skin) treatment / use in bomb calorimeter (measuring heats of combustion) / photosynthesis / respiration or breathing by divers, pilots, sick people, plants, etc

first correct…9, second correct...6, third correct …3

(*b*) The valence electrons around a central atom in a molecule determine its shape.
Explain the difference between a bonding pair of electrons and a lone pair of electrons in a molecule. **6, 3**

Bonding pair: shared pairs of electrons in a covalent bond
Lone pair: pair of electrons not involved in bonding

first correct…6, second correct...3

Copy and complete the following table: **9, 5, 4×1**

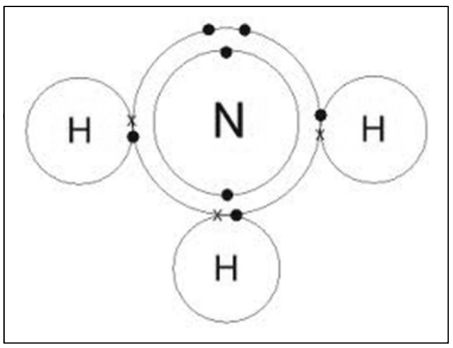
Molecule	Number of bonding pairs	Number of lone pairs	Shape of molecule
H_2S		2	
BF_3		0	
NH_3	3		

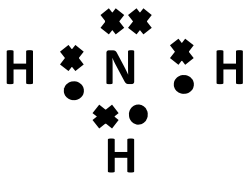
Molecule	Number of bonding pairs	Number of lone pairs	Shape of molecule
H_2S	**2**	2	**V / planar**
BF_3	**3**	0	**trigonal /** [Allow triangular]
NH_3	3	**1**	**pyramidal**

first correct …9, second correct …5, remaining 4×1

Sketch a diagram to show the arrangement of bonding pairs and lone pairs in the valence shell of nitrogen in a molecule of ammonia (NH_3). **2×3**

1 lone pair …3
3 bond pairs …3





[inner electrons not necessary; electrons pairs can be shown as any combination of dots and crosses]

(*c*) Figure 24 shows a loaf of Irish soda bread made from a recipe which includes the ingredients bread soda and buttermilk. Lactic acid ($C_3H_6O_3$) in the buttermilk reacts with the sodium hydrogencarbonate ($NaHCO_3$) in the bread soda according to the following balanced equation:

$C_3H_6O_3 + NaHCO_3 \rightarrow C_3H_5O_3Na + H_2O + CO_2$

The carbon dioxide produced in this reaction is trapped in the unbaked bread dough in small bubbles.

What is meant by a mole of a substance? **2×3**
SI unit // amount (of a substance) // molecular mass or formula mass …3
of amount (of a substance) // that contains 6×10^{23} particles or atoms or molecules // in grams …3

Find the mass of one mole of sodium hydrogencarbonate ($NaHCO_3$). **2×3**
[H = 1, C = 12, O = 16, Na = 23]
23 + 1 + 12 + (3 × 12) …3
= 84 (g) …3

When a teaspoon measure (5 g) of $NaHCO_3$ completely reacts according to the equation above, calculate

(i) the number of moles of $NaHCO_3$ used **5, 1**
($n = 5 \div 84$ = / $n = \frac{m}{M_r}$) …5
= 0.06 (moles) …1

(ii) the number of water molecules produced **5, 1**
0.06 moles water …5
($0.06 \times 6.0 \times 10^{23}$ mol^{-1} =) 3.6×10^{22} (molecules) …1

(iii) the volume of CO_2 gas produced, measured in litres at s.t.p. **5, 1**
0.06 moles CO_2 …5
0.06 × 22.4 = 1.344 (litres) …1
[Avogadro constant = $6.0 \times 10^{23} mol^{-1}$; molar volume at s.t.p. = 22.4 litres]

What would you expect the effect on the bubbles of CO_2 to be, if the bread dough mixture is put in a pre-heated oven? **3**
(bubbles) expand or increase in volume / bread rises / affects texture bread, etc …3