Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2026

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.

In considering this marking scheme for the written examination, 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. Where incorrect terminology is used or where part of the candidate's answer contradicts another part, the marks may not be awarded. Cancellation may apply when a candidate gives more than the required number of responses, or a list of correct and incorrect answers.

3. Words, expressions or statements separated by a solidus, /, are alternatives which are equally acceptable. 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 <u>alternative valid answers are acceptable</u>.

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. Material that is bracketed is not required in that year.

6. Each time an arithmetical slip occurs in a calculation, one mark is deducted ; this also applies to inappropriate or incorrect rounding of numerical answers.

7. For omission of appropriate units (or for incorrect units) in final answers, one mark is deducted, unless otherwise indicated.

8. 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. 300 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 300 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 400 @ 10%

Bain úsáid as an tábla seo i gcás na n-ábhar a bhfuil 400 marc san iomlán ag gabháil leo agus inarb é 10% gnáthráta an bhónais.

Bain úsáid as an ngnáthráta i gcás 300 marc agus faoina bhun sin. Os cionn an mharc sin, féach an tábla thíos.

Bunmharc	**Marc Bónais**
301 - 303	29
304 - 306	28
307 - 310	27
311 - 313	26
314 - 316	25
317 - 320	24
321 - 323	23
324 - 326	22
327 - 330	21
331 - 333	20
334 - 336	19
337 - 340	18
341 - 343	17
344 - 346	16
347 – 350	15

Bunmharc	**Marc Bónais**
351 – 353	14
354 – 356	13
357 – 360	12
361 – 363	11
364 – 366	10
367 – 370	9
371 – 373	8
374 – 376	7
377 – 380	6
381 – 383	5
384 – 386	4
387 – 390	3
391 – 393	2
394 – 396	1
397 – 400	0

1. Answer eleven of the following items (a), (b), (c), etc. All the items carry equal marks. Keep your answers short.

(*a*) State the SI unit of energy.
joule / J **[6]**
[accept partial answer for 3]

(*b*) Calculate the weight of a tiger with a mass of 265 kg. [acceleration due to gravity, g = 9.8 m s^{-2}]
265 × 9.8 = 2597 N **[6]**
[accept partial answer for 3]

(*c*) State one difference between a scalar and a vector quantity.
vector quantities have a direction **[6]**
[accept partial answer for 3]

(*d*) Calculate the acceleration of an object of mass 18 kg when a force of 8.5 N is applied.
a $= \frac{8.5}{18}$ **= 0.472 m s^{-2}** **[6]**
[accept partial answer for 3]

(*e*) Pure aluminium metal melts at 660 °C. Convert this temperature to its value on the Kelvin scale.
660 + 273 = 933 K **[6]**
[accept partial answer for 3]

(*f*) The wavefronts shown diffract as they pass through the gap.
Copy and complete the diagram to show this wave undergoing diffraction.

diagram to show: at least one wave spreading out from the slit **[6]**
[accept partial answer for 3]

(*g*) State one example of a longitudinal wave.
any correct example **[6]**
[accept partial answer for 3]

(*h*) Name two regions of the electromagnetic spectrum.
microwave, infra-red, visible light, ultra-violet, X-rays, gamma rays **[*any two*]** **[4+2]**

(*i*) State one common use for a concave mirror.
any correct use e.g. magnification **[6]**
[accept partial answer for 3]

(*j*) Calculate the focal length of a concave mirror with a radius of curvature of 10 cm.
10 ÷ 2 = 5 (cm) **[6]**
[accept partial answer for 3]

(*k*) What is observed as a negatively-charged rod approaches the cap of a positively charged electroscope?
leaf collapses
[6]
[accept partial answer for 3]

(*l*) State two effects of an electrical current.
magnetic, heating, chemical **[any two]** **[4+2]**

(*m*) Calculate the effective resistance of two 330 Ω resistors connected in series.
330 + 330 = 660 **[6]**
[accept partial answer for 3]

(*n*) Name the phenomenon that results in the release of electrons from the surface of a metal when light of a suitable frequency falls on it.
photoelectric effect **[6]**
[accept partial answer for 3]

(*o*) Sketch the magnetic field around a bar magnet.
diagram to show magnet, field lines and correct direction **[6]**
[accept partial answer for 3]

(*p*) State the principle on which the moving-coil galvanometer is based.
current carrying coil in a magnetic field
experiences a force **[4+2]**

(*q*) Name a device used to detect nuclear radiation.
Geiger counter **[6]**
[accept partial answer for 3]

(*r*) State two types of nuclear reaction.
fission, fusion **[4+2]**
[accept partial answer for 3]

2. (a) A rider on an e-scooter maintains the maximum legal velocity of 20 kilometres per hour for 2 minutes on a road.

(i) What is the meant by velocity?

rate of change of displacement / speed in a given direction / s ÷ t **[5]**

[accept partial answer for 3]

(ii) Convert 20 kilometres per hour to metres per second.

20 km = 20000 m **[3]**

1 hour = 3600 s **[3]**

20000 ÷ 3600 = 5.6 (ms^{-1}) **[3]**

(iii) Calculate the maximum distance travelled in the 2-minute interval.

5.6 × 120 = 672 m **[6]**

[accept partial answer for 3]

(iv) Calculate how long it would take, at this velocity, to travel 2.5 kilometres.

20 = 2.5 ÷ t **[3]**

t = 0.125 hours / 7.5 min **[4]**

(b) The table shows the velocity of an e-scooter at constant time intervals along a road.

Time (s)	0.0	0.5	1.0	1.5	2.0	2.5
Velocity (m s^{-1})	0.0	0.8	1.6	2.4	3.2	4.0

(i) Draw a graph on graph paper of velocity (y-axis) against time (x-axis).

labelled axis **[5]**

points plotted **[6 × 1]**

line **[3]**

[max 3x1 if not on graph paper]

(ii) How does your graph show that the e-scooter is experiencing acceleration?

sloped / **[3]**

line (starting at origin) **[3]**

(iii) Use your graph to estimate the time it takes for the e-scooter to reach a velocity of 3.0 m s^{-1}.

value from graph

≈ 2 S **[5+1]**

(iv) Calculate the acceleration of the e-scooter.

correct formula

substitution

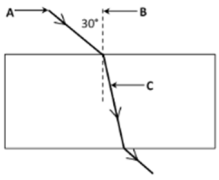
≈ 1.6 ms^{-2} **[5+2+2]**

(v) State two factors which determine the maximum acceleration of an e-scooter.

mass (of scooter)

forces (on scooter) / friction / gravity *etc.* **[2+2]**

3. (*a*) The diagram below shows how a ray of light travels through a rectangular glass block.



(*i*) What is meant by the refraction of light?

the bending of light **[6]**

(*ii*) Identify A, B and C.

A = incident **[3]**

B = normal /perpendicular **[3]**

C = refracted **[3]**

[reflected instead of refracted -1]

The light ray strikes the glass block at an angle of 30° and undergoes refraction as it travels from air to glass. The angle of refraction is 19.5°.

(*iii*) Calculate *n*, the refractive index of the glass block.

n* = sin *i*/sin *r **[3]**

substitution **[3]**

n = 1.5 **[3]**

(*b*) The diagram shows a ray of monochromatic light entering a fibre optic cable.

(*i*) Copy and complete the diagram to show how light is transmitted along an optical fibre.

internal reflection shown in path of ray in fibre **[6]**

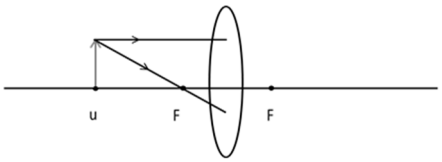
(*ii*) Name the phenomenon that allows light to travel through an optical fibre without escaping.

total internal reflection **[6]**

(*iii*) State one use of an optical fibre.

e.g. broadband cables **[6]**

(*c*) The diagram below shows two rays travelling towards a converging (convex) lens.



(*i*) Copy and complete the diagram to show the paths of the rays of light after they strike the converging lens.

ray emerging through F **[3]**

ray emerging parallel **[3]**

[accept partial answer for 3]

A converging lens has focal length *f* of 2 cm. An object *u* is placed 6 cm in front of the lens.

(*ii*) Calculate the image distance, *v*.

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

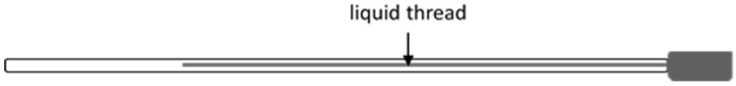
v = 3 cm **[3]**

(*iii*) Calculate the magnification, *m*.

m = $\frac{v}{u}$ /substitution **[6]**

m = 0.5 **[3]**

4. (*a*) A temperature scale can be defined in terms of changes of a physical property such as the length of an enclosed liquid as in a laboratory thermometer.



(*i*) What term is used to describe a physical property that changes measurably with temperature?
thermometric

(*ii*) State another example of a physical property that changes measurably with temperature.
e.g. volume, emf, pressure, resistance etc.

(*iii*) State the two fixed points used to establish the Celsius temperature scale on a laboratory thermometer.
0
100

(*iv*) Describe an experiment to locate these fixed points on an unmarked laboratory thermometer.
place unmarked thermometer in crushed ice and water
place unmarked thermometer in the boiling water
[*Note: full marks may be awarded for a suitable labelled diagram*]

[9+6+6+2+2+2]

(*b*) The following table shows the data obtained in an experiment to establish the calibration curve of a thermometer.

Temperature (°C)	0	20	40	60	80	100
Length (mm)	20	48	76	104	132	160

(*i*) Draw a graph on graph paper of length (*y*-axis) against temperature (*x*-axis).
axis labelled correctly **[6]**
6 points plotted correctly **[6x1]**
line of best fit **[3]**
[max 3x1 if not on graph paper]

(*ii*) Use your graph to estimate the length of the liquid thread of the liquid at 56 °C.
value from graph
≈ 98 mm **[7+2]**

(*iii*) Calculate the change in length of the thread for every degree change in the temperature.
values from table or graph
division
≈ 1.4 mm **[9+2+2]**

Some laboratory thermometers contain the liquid metal mercury (**Hg**).

(*iv*) State two reasons why mercury is suitable for use in a thermometer.
high thermal conductivity // expands uniformly //
high boiling point // low freezing point **[*any two*]** **[1+1]**

5. (*a*) A mains powered television is rated at 0.091 kW when in use and 0.0005 kW when in standby mode.

(*i*) What replaceable safety device inside a three-pin plug is used to connect to a mains supply?

fuse **[3]**

(*ii*) State two energy conversions that take place when the television is switched on.

electrical to **[2]**

heat/light/sound/kinetic energy [any two] **[2x5]**

(*iii*) Calculate the number of kilowatt hours (kW h) consumed by the television when used for 3 hours each day.

0.091 × 3

0.273 (kWh) **[4+2]**

For the remainder of each day (21 hours) the television is in standby mode.

(*iv*) Calculate the total number of kilowatt hours (kW h) consumed by the television in one day.

0.0005 × 21 = 0.0105 (kWh)

0.273 + 0.0105 = 0.2835 (kWh) **[4+2]**

(*v*) Calculate the total cost of running the television for 28 days if the cost per kW h is 35 cent.

0.2835 × 28 days = 7.938 kWh

7.938 × 35 = 273.83c /€2.74 **[4+2]**

(*b*) The following terms are used in expressing Coulomb's law of electrical forces:

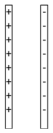
distance Inversely product square two

(*i*) Copy and complete the following statement of Coulomb's law in your answerbook:

"The force between **two** charged particles is directly proportional to the **product** of the charges and is **inversely** proportional to the **square** of the **distance** between the charges.

[7+2+2+2+2]

The diagram shows the plates of a charged parallel-plate capacitor.



(*ii*) Copy the diagram into your answer book showing the electric field between the plates and its direction.

straight parallel lines between plates

from positive to negative **[4+2]**

(*iii*) What happens to the electric field between the plates when they are discharged?

collapses **[3]**

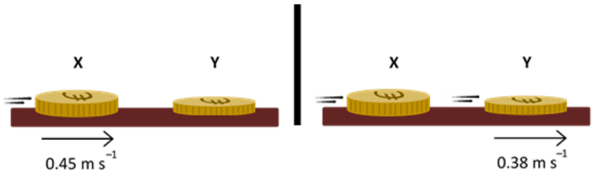
(*iv*) State three factors which affect the capacitance of a parallel-plate capacitor.

distance between plates

permittivity

area of overlap **[5+2+2]**

6. (*a*) A coin, X, of mass 24 g moving at a velocity of 0.45 m s^{-1} slides along a smooth horizontal table top. It collides with a smaller coin, Y, of mass 16 g which is stationary. After the collision both coins move off in the same direction with coin Y moving at 0.38 m s^{-1}.



(*i*) What is meant by momentum?
mass × velocity / *mv* **[6]**

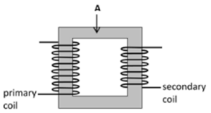
(*ii*) State the principle of conservation of momentum.
(in a closed system, the total) momentum before (interaction) =
(the total) momentum after / $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ **[6]**

(*iii*) Calculate the momentum of coin **X** *before* the collision.
substitution **[3]**
≈ 0.0108 (kg ms^{-1})/10.8(gms^{-1}) **[3]**

(*iv*) Calculate the velocity of coin **X** *after* the collision.
substitution of values into correct formula **[6]**
0.197(ms^{-1}) **[3]**

(*v*) Why does coin **Y** not contribute to the total momentum before the collision?
no velocity/not moving **[6]**

(*b*) An electrical transformer is based on the principle of electromagnetic induction and is used with a.c. voltage sources.



(*i*) What is meant by a.c. voltage?
reverses direction(over time) / suitable diagram **[6]**
[accept partial answer for 3]

(*ii*) Explain the term electromagnetic induction.
voltage induced by a moving magnet **[6]**
[accept partial answer for 3]

(*iii*) Identify the part labelled **A** on the electrical transformer shown.
(soft) iron core **[3]**

A transformer with 4900 turns on its primary coil is connected to a 1000 V a.c. source.

(*iv*) Calculate the number of turns on the secondary coil when the output voltage is 230 V a.c.
$\frac{V_s}{V_p} = \frac{N_s}{N_p}$ **[6]**
substitution **[3]**
1127 **[3]**

(*v*) Why are high voltages used to transmit electrical power over long distances?
to prevent loss of energy through heat **[6]**

(*c*) Many discoveries about the nature of matter are based on the study of gases and their properties. Consider the descriptions in the table below.

(*i*) In your answerbook match each term to its description (**A**, **B**, **C**, etc.) in the table.

Letter	Description
A	**Brownian**
B	**Boyle**
C	**mass**
D	**Charles**
E	**ideal**
F	**Kelvin**
G	**halving**
H	**doubling**

[8+8+8+(5 × 1)]

The kinetic theory of gases makes predictions about the particle nature of gases.

(*ii*) State two assumptions of the kinetic theory of gases.
particles in constant motion
volume occupied (by particles) is negligible **[2+2]**

(*d*) In 1977 the Voyager 2 space probe was launched on an initial trajectory to pass Uranus and Neptune and in 2026 continues to send back data from interstellar space. Voyager 2 is powered using the energy released during the decay of plutonium-238 which is a radioactive isotope with a half-life of 88 years.

(*i*) What is meant by the half-life of a radioactive isotope?
time for half the nuclei in a sample to decay **[6]**
[accept partial answer for 3]

(*ii*) How many years since the launch of Voyager 2?
49 **[3]**

(*iii*) Does Voyager 2 currently have more than 50% of its power source remaining?
State a reason for your answer.
yes
half life is 88 years etc **[4+2]**

During the radioactive decay of plutonium-238 a stream of alpha-particles is emitted.

(*iv*) Describe the structure of an alpha particle.
helium nucleus / two protons and two neutrons/ $\mathbf{{}_2^4He}$ **[3]**

(*v*) How could a stream of alpha particles be deflected?
electromagnetic fields /charged plates / charge **[3]**

(*vi*) State two other types of nuclear radiation.
beta **[6]**
gamma **[6]**

7. Answer eleven of the following items (a), (b), (c), etc. All the items carry equal marks. Keep your answers short.

(*a*) Draw the shape of (*i*)an *s* orbital,(*ii*)a *p* orbital.
spherical
dumbell **[4+2]**

(*b*) Identify two elements with the same group number as krypton (Kr).
He / Ne / Ar etc **[4+2]**

(*c*) Copy and complete the following statement:
Allotropes are different **structural** forms of the same **element (atom)** **[4+2]**

(*d*) State two characteristic properties of transition metal compounds.
variable valency // colourful etc. **[4+2]**

(*e*) Carbon–14 is a naturally occurring radioactive isotope used in archaeology.
Explain the term isotope.
same atomic number / same number of protons
different mass numbers / different number of neutrons **[4+2]**

(*f*) State two possible shapes of a molecule with the general formula AB_2.
linear
v-shaped **[4+2]**

(*g*) Calculate the volume occupied by 2.5 moles of argon gas at s.t.p. [Molar volume at s.t.p=22.4L]
2.5 × 22.4 = 56L **[6]**
[*3 marks for partial answer*]

(*h*) Calculate the percentage by mass of oxygen in hydrogen peroxide (H_2O_2). [H = 1, O = 16]
Mr = 34 **[2]**
32 ÷ 34 **[2]**
× 100 = 94 % **[2]**

(*i*) A hot air balloon contains 1.5×10^5 moles of nitrogen gas. How many molecules of nitrogen does it contain? [Avogadro constant = 6×10^{23} mol^{-1}]
$1.5 \times 10^5 \times 6 \times 10^{23} = 9 \times 10^{28}$ **[6]**
[*3 marks for partial answer*]

(*j*) State the role of a catalyst in a chemical reaction.
speeds up a (chemical) reaction **[6]**

(*k*) What is a hydrocarbon?
contains carbon and hydrogen (only) **[6]**

(*l*) Balance the following equation:
2$FeCl_2 + Cl_2 \rightarrow$ **2**$FeCl_3$ **[4+2]**

(*m*) Calculate the pH of 0.018 M solution of nitric acid (HNO_3).
pH = –log(0.018) / pH = –log(H^+)
= 1.7 **[4+2]**
[*3 marks for partial answer*]

(*n*) Identify two gases produced when acidified water undergoes electrolysis.
Hydrogen /H_2
Oxygen / O_2 **[4+2]**

(*o*) List the following elements in their order in the electrochemical series.
potassium_copper_zinc **[6]**
[*3 marks for partial answer*]

(*p*) How many electrons are present in the triple bond between the two carbon atoms in ethyne (C_2H_2)?

6 **[6]**

[*3 marks for partial answer*]

(*q*) Copy the structural formula for phenol and circle the hydroxyl group.

correct group circled **[6]**

(*r*) State one use for ethanoic acid.

food flavouring etc. **[6]**

[*3 marks for partial answer*]

8. All known elements are arranged on the periodic table by increasing atomic number. The location of elements can be used to predict trends in their structure and properties.

Element	lithium (Li)	chlorine (Cl)
Atomic number	S	V
Group number	T	W
Period number	2	X
First ionisation energy (kJ mol^{-1})	520	Y
Electronegativity	U	Z

(a) You should use the information found on pages 79, 80 and 81 of the Formulae and Tables booklet when answering this question.

(i) Identify the values S, T and U for the element lithium (Li) shown in the table above.

S = 3

T = 1

U = 0.98

(ii) Identify the values V, W, X, Y and Z for the element chlorine (Cl) shown in the table above.

V = 17

W = 7 / 17

X = 3

Y = 1251

Z = 3.16 **[8+8+5+(5×1)]**

(iii) What do elements in the same group have in common?

same properties / same number of electrons on outer shell **[2]**

(iv) Write the electronic configuration for an atom of chlorine (Cl).

2,8,7 / $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^5$ **[2]**

(v) What is meant by the first ionisation energy of an atom of an element?

(minimum) energy required **[2]**

to remove (the mostly loosely bound) or outer)electron **[2]**

(vi) State a reason why there is a large difference in first ionisation energy between lithium and chlorine.

lithium 1 electron on outer shell /chlorine has 7 electrons on outer shell **[2]**

(b) The type of bonding in a compound is related to the electronegativity values of the elements it contains.

(i) Use electronegativity values to show that the bonding in lithium chloride (LiCl) is ionic.

getting values 3.16 and 0.98

2.18

greater than 1.7 **[6+2+2]**

(ii) Draw a dot and cross diagram to show the arrangement of the valence electrons in LiCl.

correct electrons and charge on lithium **[2+2]**

correct electrons and charge on chlorine **[2+2]**

The arrangement of ions in a crystal of lithium chloride is shown.

(iii) What is the maximum number of chloride ions that can surround (as its nearest neighbours) a lithium ion in the crystal?

6 **[6]**

(iv) State two conditions in which lithium chloride crystals conduct electricity.

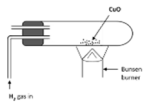
Molten / liquid **[2]**

dissolved in water **[2]**

(v) What type of bonding exists between the atoms in a sample of pure lithium?

metallic **[2]**

9. (*a*) A stream of hydrogen gas (H_2) passed over a heated sample of copper oxide (CuO) will cause the hydrogen gas to be oxidised.



(*i*) What other chemical process also occurs as the hydrogen is oxidised?
reduction

(*ii*) Copy and complete the equation for the reaction:
$CuO + H_2 \rightarrow$ **Cu** + **H_2O**

Steam (H_2O) reacts with magnesium (Mg) according to the following equation
$H_2O + Mg \rightarrow MgO + X$

(*iii*) Identify substance X.
H_2

(*iv*) Is H_2O or Mg oxidised in this reaction? State a reason for your answer.
Mg
gains oxygen/loses electrons **[9+9+9+3+3]**

(*b*) (*i*) What is an acid according to the Brønsted-Lowry theory?
proton donor **[6]**
[*3 marks for partial answer*]

(*ii*) Identify the two acids in the following reaction: $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$
H_2O **[3]**
NH_4^+ **[3]**

(*iii*) State one example of an acid-base conjugate pair in the above reaction.
$NH_3 \rightleftharpoons NH_4^+$ / $H_2O \rightleftharpoons OH^-$ **[6]**

(*iv*) Identify the two bases in the following reaction:
$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$
H_2O **[3]**
$H_2PO_4^-$ **[3]**

The two given reactions in part (*b*) show the amphoteric nature of water.

(*v*) What is meant by the term amphoteric?
can act as an acid and a base **`[3]**

(*vi*) How do the equations show that water is amphoteric?
$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ - **water acts as an acid**
$H_3PO_4 + H_2O \rightleftharpoons H_2PO_4^- + H_3O^+$ - **water acts as a base** **[6]**
[*3 marks for partial answer*]

10. (*a*) The diagram shows a standard solution of hydrochloric acid (HCl).

(*i*) What is meant by the term standard solution?

(solution of)known concentration **[3]**

(*ii*) Identify the safety pictogram on the label.

corrosive **[3]**

(*iii*) State two types of personal protective equipment to be worn when using this acid.

labcoat / glasses / gloves etc. **[*any two*]** **[6+3]**

(*b*) Some of this acid was used in a titration with a solution of sodium hydroxide (NaOH). In preparation for the titration 20.0 cm^3 of the solution of sodium hydroxide (NaOH) was accurately measured using a pipette and transferred into a conical flask.

(*i*) Describe how the pipette was rinsed before use.

with deionised water

with solution **[4+2]**

(*ii*) Describe a procedure for accurately transferring 20.0 cm^3 of NaOH to the conical flask.

use pipette filler/

allow solution to drain under gravity (into conical flask)/

touch the tip to the neck of the flask (to dislodge drop clinging to tip)/ do not blow out the last drop **[12]**

(*iii*) Explain why a conical flask is a suitable piece of glassware when reacting the solutions.

swirl without spilling etc **[3]**

(*iv*) What is the purpose of using an indicator in a titration?

to detect / see the endpoint /acid base react **[3]**

(*v*) Explain why a wash bottle is used to rinse the inside of the conical flask during the titration.

to make sure all acid and base react / accuracy *etc* **[3]**

(*c*) The titration was completed when 19.8 cm^3 of 1.6 M hydrochloric acid (HCl) reacted with 20.0 cm^3 of the sodium hydroxide solution (NaOH). The reaction can be described by the following balanced chemical equation: $HCl + NaOH \rightarrow NaCl + H_2O$

(*i*) Name a suitable indicator for this titration.

phenolphthalein /methyl orange (red) **[3]**

(*ii*) State the colour change observed at the end point.

pink // yellow or orange **[3]**

to colourless// pink or red **[3]**

[*3 marks if correct colours reversed*]

(*iii*) Calculate the concentration of the NaOH solution in moles per litre.

$\frac{(\mathbf{19.8})(\mathbf{1.6})}{\mathbf{1}}$ **[3]**

$\frac{(\mathbf{20.0})(\boldsymbol{M2})}{\mathbf{1}}$ **[3]**

≈1.6 (M) **[3]**

[correct formula only…. max 6 marks]

(*iv*) Why should the titration be repeated a number of times?

accurate result etc **[6]**

11. (*a*) Ethanol (C_2H_5OH) is the second member of its homologous series.

(*i*) Name the homologous series to which ethanol belongs.

alcohol **[6]**

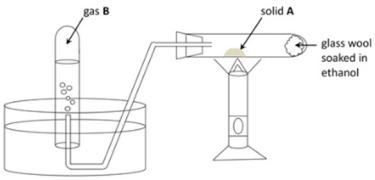
(*ii*) Draw the molecular structure of ethanol showing all atoms and all bonds.

correct structure **[6]**

[*3 marks for partial answer*]

(*iii*) State the IUPAC name of the first member of the same homologous series.

methanol **[6]**



The diagram below shows the apparatus used to convert ethanol to an unsaturated hydrocarbon containing two carbon atoms.

(*iv*) Identify solid A.

aluminium oxide / Al_2O_3 **[3]**

(*v*) Identify gas B.

ethene **[3]**

(*vi*) What is meant by the term unsaturated hydrocarbon?

contains C to C double / triple bond **[3]**

(*vii*) Describe a test to show that gas B is unsaturated.
Your answer should include all apparatus used and observations made.

in a test tube
bromine water / acidified potassium permanganate(mixed with gas)
solution decolourises / correct colour change to match reagent used

Any two **[6+3]**

(*b*) The combustion of sulfur can be described using the following balanced chemical equation: $S + O_2 \rightarrow SO_2$ $\Delta H = -297$ kJ mol^{-1}

(*i*) What is meant by the heat of combustion (ΔH) of a substance?

heat released
when one mole of a substance
is burnt completely in oxygen **[4+3+2]**

(*ii*) Is this reaction *exothermic* or *endothermic*? Explain your answer.

exothermic
ΔH is negative/ its combustion **[6+3]**

(*iii*) Calculate the heat change when 20 moles of sulfur (S) are reacted with oxygen.

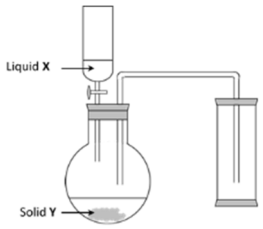
20 × 297 = 5940 (kJ) **[6]**

(*iv*) Why should the amount of SO_2 released into the atmosphere be limited?

acidic oxide / causes acid rain **[6]**

[*3 marks for partial answer*]

12. (*a*) Carbon dioxide (CO_2) can be prepared and collected using a laboratory set up as shown.



(*i*) Identify liquid X.
X = hydrochloric acid / HCl **[2]**

(*ii*) Identify solid Y.
calcium carbonate /$CaCO_3$ **[2]**

(*iii*) What does this method of collection tell you about the density of CO_2 compared to the density of air?
it is denser than air / heavier **[12]**

(*iv*) Describe a test to verify that the gas jar is full of CO_2.
lit splint (into the jar)
it will extinguish / flame will go out **[10 +3]**

(*v*) Describe a chemical test to verify that CO_2 is an acidic gas.
litmus / universal indicator (into the jar)
goes red / result **[2+2]**

(*b*) Magnesium (Mg) metal reacts with sulfuric acid (H_2SO_4) according to the following balanced chemical equation:

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

(*i*) What is meant by a mole of a substance?
6.0×10^{23} (particles) **[3]**

(*ii*) State the mass of one mole of magnesium.
24.31 g /24 **[6]**
[*3 marks for partial answer*]

(*iii*) How many moles of magnesium atoms are present in 120 g of the metal?
120 ÷ 24.31 =4.94 **[6]**
[*3 marks for partial answer*]

(*iv*) Calculate the mass of $MgSO_4$ produced when 120 g of magnesium fully react.
Mr = 120
$4.94 \times 120 = 592.8$ g **[6+3]**

(*v*) How many molecules of H_2 gas are produced when 120 g of magnesium fully react?
4.94 moles
$\times 6.0 \times 10^{23} = 2.964 \times 10^{24}$ **[6+3]**

(*c*) Some chemical elements react with oxygen to form stable compounds known as oxides.

(*i*) State the formula of the oxides U, V and W in the table below.

U = Na_2O

V = CaO

W = Al_2O_3 **[5+2+2]**

(*ii*) State the names of the oxides X, Y and Z in the table below.

X = sodium oxide

Y = carbon monoxide

Z = aluminium oxide **[5+2+2]**

	sodium (Na)	calcium (Ca)	carbon (C)	aluminium (Al)
formula of oxide	U	V	CO	W
name of oxide	X	calcium oxide	Y	Z

Water (H_2O) is the only oxide found naturally on earth in the three states of matter.

(*iii*) State the shape of the H_2O molecule.

v shaped/bent **[3]**

(*iv*) Draw a diagram of a H_2O molecule showing the arrangement of bonding pairs and lone pairs of electrons.

correct diagram **[6]**

[3 marks for partial answer]

(*v*) What type of intermolecular forces exist between molecules of water in its solid state?

hydrogen bonding/van der waals / dipole-dipole **[6]**

[3 marks for partial answer]