Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2025

Marking Scheme

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 – words that must appear in the correct context in the candidate's answer in order to merit the assigned marks.
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.

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

3. A double solidus, //, separates 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.
Material that is bracketed is not required in that year.

6. When a candidate is asked to identify a chemical substance, either the name or formula is accepted, unless otherwise indicated. For *deionised water*, the term *distilled water* or *pure water* should also be accepted, unless otherwise indicated. For organic compounds the IUPAC name or traditional scientific name is acceptable, unless otherwise indicated. Inorganic compounds may be named using oxidation state or traditional naming convention – e.g. potassium manganate(VII) or potassium permanganate for $KMnO_4$.

7. Each time an arithmetical error occurs in a calculation, one mark is deducted; this also applies to inappropriate or incorrect rounding of numerical answers. This deduction applies to incorrect M_r values, but only if a candidate shows the addition of all the correct atomic masses and the error is clearly an arithmetical one. If the addition of atomic masses is not shown, the candidate loses the marks for an incorrect M_r.

8. For drawing the molecular structure of an organic compound, one mark is deducted if the H atoms are omitted in a systematic way and one mark is deducted if bonds to H atoms are omitted in a systematic way.

9. A zero should only be recorded when the candidate has attempted the question item but does not merit marks. If a candidate does not attempt a question item examiners should record NR.

10. Examiners are expected to annotate each part of the candidate's response as directed at the marking conference.

For a fully correct response, examiners may award one total mark (e.g. 6 marks) or a number of partial marks (e.g. 2 marks, 2 marks, 2 marks) that add to the same total.

For an incorrect or partially incorrect response examiners should place the appropriate annotations near the correct/incorrect elements of the response such that a total mark is generated for the response (e.g. 2 marks, 0 marks, 2 marks).

Symbol	Name	Use
	Cross	Incorrect element
	Tick	Correct element (0 marks)
	Tick_n	Correct element (n marks)
	Horizontal wavy line	To be noticed
	Vertical wavy line	Additional page
	Ellipse	Incorrect material
-1	−1	−1
0	0	0
^	^	Missing element
C	C	Cancellation
[	Square bracket	Surplus element

12. 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. Soap is a product of the reaction between a solution of sodium hydroxide (NaOH) and a common household substance A.

A student mixed suitable amounts of substance A with solid NaOH in a solvent mixture of water and ethanol. The mixture was heated gently for about 20 minutes using a hot-water bath, as shown in Diagram 1.

Diagram 1

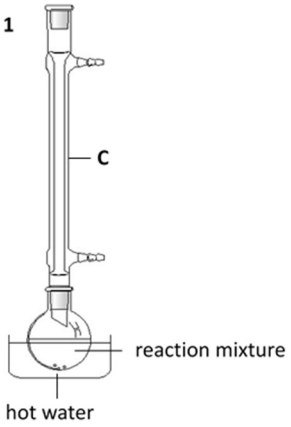
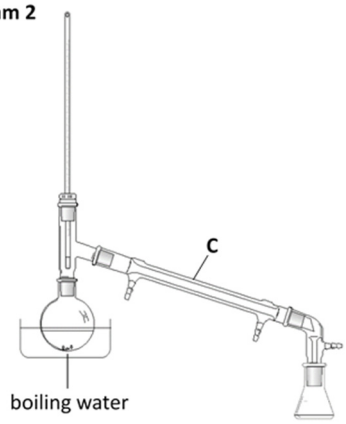


Diagram 2



Ethanol was then removed from the reaction mixture as shown in Diagram 2.

Some boiling water was used to transfer the residue in the round-bottomed flask into brine in a beaker, precipitating soap.

(*a*) Identify substance A.

fat / oil **(6)**

(*b*) (*i*) Name the technique shown in Diagram 1, which is used to heat the reaction mixture without loss of solvent.

reflux **(6)**

(*ii*) Name the technique shown in Diagram 2, which is used to separate the ethanol from the reaction mixture.

distillation **(6)**

(*c*) (*i*) Name the piece of apparatus labelled C in the diagrams.

(liebig) condenser **(6)**

(*ii*) Identify the change of state that occurs in C.

gas (vapour) **(3)**

to liquid **(3)**

[award 3 marks if reversed] [allow 3 marks for condensation]

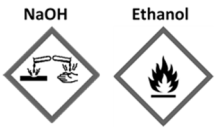
(*d*) (*i*) What is brine?

(saturated) salt solution **(6)**

(*ii*) Describe how the soap precipitate could have been separated from the brine.

filtration / labelled diagram **(6)**

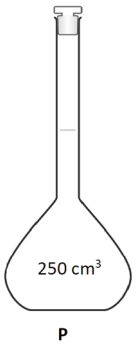
(*e*) Warning pictograms found on containers of NaOH and ethanol are shown on the right. State the chemical hazard indicated by each of these pictograms.



corrosive **(4)**

flammable **(4)**

2. A student used a standard solution of sodium carbonate (**Na_2CO_3**) to find the concentration of a solution of hydrochloric acid (**HCl**) by titration. The sodium carbonate solution was supplied in the piece of apparatus labelled **P**. Some of this solution was placed in a clean, dry beaker. 25.0 cm^3 portions were measured using another piece of apparatus and then transferred to a conical flask. The solution was titrated against **HCl**, which was added from a burette. A number of titrations were carried out.



(*a*) The sodium carbonate solution used was a standard solution.
Explain the underlined term.
a solution of known concentration **(5)**

(*b*) (*i*) Identify the piece of apparatus labelled **P**.
volumetric flask

(*ii*) Name a suitable piece of apparatus that can be used to accurately measure out a 25.0 cm^3 portion of the sodium carbonate solution.
pipette / burette

(*iii*) Describe how the burette was rinsed before use.
deionised water
(HCl) solution ***[–1 if reversed]***

(*iv*) State one precaution that could be taken to ensure accuracy when taking a burette reading.
read from eye level / meniscus on mark / burette clamped vertically
(9 + 9 + 2 + 2 +2)

(*c*) A few drops of an indicator solution were added to the **Na_2CO_3** in the conical flask before carrying out each titration.

(*i*) Name a suitable indicator.
methyl orange / methyl red **(3)**

(*ii*) State the colour change observed in the conical flask at the end point using this indicator.
yellow / orange **(3)**
to pink / peach / red ***[3 marks if colours reversed]*** **(3)**

(*iii*) Why is it helpful to place the conical flask on a white tile during the titration?
to see the colour change more clearly **(3)**

(*d*) On average, it was found that 25.0 cm^3 portions of a 0.05 M **Na_2CO_3** solution required 18.4 cm^3 of a **HCl** solution for neutralisation.
The titration reaction is described by the following balanced chemical equation:

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

Calculate the concentration, in moles per litre, of the **HCl** solution.

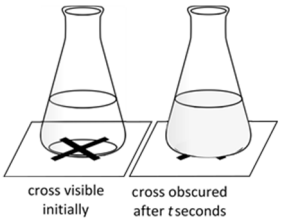
$\frac{M \times 18.4}{2}$ **/** $\frac{(0.05)(25)}{1000}$ **= 0.00125 (moles per 25 cm^3)**

$\frac{25 \times 0.05}{1}$ **/** **0.00125 × 2 = 0.0025**

0.13 - 0.14 M **/** $\frac{(0.0025)(1000)}{18}$ **= 0.13 - 0.14 M** **(5 + 2 + 2)**

[award 5 marks for formula/ implied if no other marks awarded]

3. 10 cm^3 of 3 M hydrochloric acid (HCl) were added to a flask containing 100 cm^3 of sodium thiosulfate ($Na_2S_2O_3$) solution. The flask was swirled to mix the solutions. The solution gradually turned pale yellow and cloudy. A timer was used to find the time taken in minutes for a cross marked on a piece of paper placed under the flask, to become obscured, when looking down through the reaction mixture. The reaction observed in the flask is described by the following balanced chemical equation:



$$Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(g)} + S_{(s)} + H_2O_{(aq)}$$

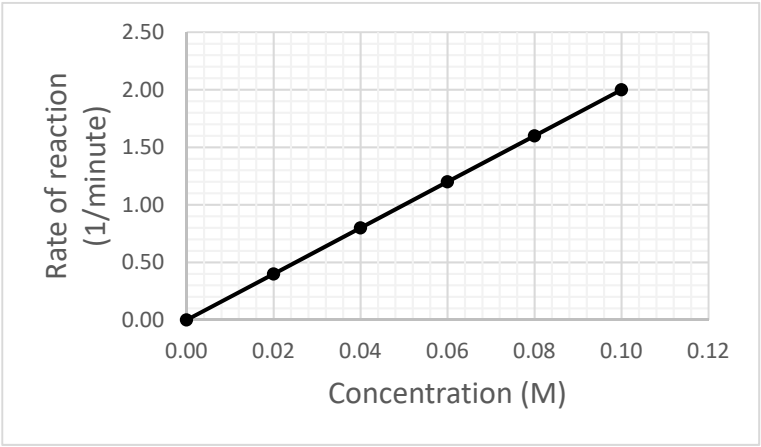
The rate of reaction (1/minutes) for a number of different concentrations of $Na_2S_2O_3$ was measured and the data recorded in the table below. All other reaction conditions were kept constant.

Concentration of $Na_2S_2O_3$ (M)	0	0.02	0.04	0.06	0.08	0.1
Rate of reaction (1/minutes)	0	0.4	0.8	1.2	1.6	2.0

(*a*) (*i*) Identify the reaction product that causes the cross to become obscured.
sulfur / S **(5)**

(*ii*) Name a suitable piece of apparatus that could be used to measure out 10 cm^3 of HCl.
graduated cylinder **(6)**

(*iii*) State one reaction condition which was kept constant.
temperature / volume / container **(6)**



(*b*) (*i*) Plot a graph, on graph paper, of concentration of **$Na_2S_2O_3$** versus the rate of reaction.
labelled axis **(3)**
scaled axes **(3)**
points plotted **(6 × 1)**
line of best fit **(3)**
[maximum of 12 marks if graph paper is not used]

(*ii*) Use your graph to estimate the rate of reaction when the concentration of $Na_2S_2O_3$ was 0.05 M.
rate read from graph ***[≈ 1.0 min^{-1}]*** **(6)**

(*iii*) State whether the rate of reaction increases or decreases as the concentration of $Na_2S_2O_3$ increases. Give a reason for your answer.
increases
more collisions **(4 + 2)**

(*iv*) How would you expect the rate of reaction to be affected by cooling the solutions used? Give a reason for your answer.
decrease
less energy / fewer collisions **(4 + 2)**

4. Eight items to be answered. Six marks to be allocated to each item and one additional mark to be added to each of the first two items attempted.

(*a*) Name the metal responsible for the yellow colour of the flame in a flame test.
sodium / Na **(6)**

(*b*) Describe the trend in the size of atomic radii going down Group 1 of the periodic table of elements. Give a reason for your answer.
increases
additional shells **(4 + 2)**

(*c*) State the shape of a molecule of ammonia (NH_3).
pyramidal **(6)**

(*d*) State the relationship between the temperature on the Kelvin scale and the volume of a fixed mass of gas at constant pressure according to Charles' Law.
(directly) proportional **(6)**

(*e*) What is meant by electronegativity?
(relative) attraction
for a pair of electrons **(4 + 2)**

(*f*) Calculate the percentage of carbon by mass in heptane (C_7H_{16}).
M_{total} = 100 **(2)**
7 × 12 = 84 **(2)**
$\frac{84}{100} \times 100$ **= 84 %** **(2)**

(*g*) Explain why mercaptans are added to natural gas before it is supplied to customers.
safety / noticeable smell / bad smell **(6)**

(*h*) Copy and complete the following sentence:
speeds
stationary **(4 + 2)**

(*i*) State one difference between temporary hardness and permanent hardness in water.
temporary hardness removed by boiling **(6)**

(*j*) The molecular formula of ethanoic acid is $C_2H_4O_2$. What is the empirical formula for ethanoic acid?
CH_2O **(6)**

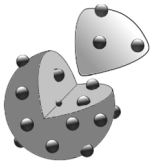
(*k*) Diffusers are used to perfume a room. The fragrant oils in the solution evaporate and diffuse into the air. What is diffusion?
movement of a substance / spreading out of a substance **(6)**

(*l*) Answer part A *or* part B.

A Write the chemical formula for ozone.
O_3 **(6)**

B Name the English scientist who discovered in 1807 that the elements sodium and potassium could be extracted from their salts by electrolysis.
(Humphrey) Davy **(6)**

5. Between 1808 and 1913 scientists gave different descriptions for the structure of the atom. Each description was 'correct' when it was first stated, because it was based on the evidence available at the time. Each description was an improvement on the previous one because it accounted for more facts known at the time. In 1808 Dalton described atoms as indivisible. By 1897 it had been discovered that all atoms contain negative particles. From this, it was proposed that the atom is spherical, with small negative particles embedded in positive matter. In 1909 Rutherford discovered that the electrons in an atom occupy an electron cloud surrounding a nucleus. In 1913 Bohr described the arrangement of the electrons in fixed paths in the electron cloud.



(*a*) (*i*) Name the scientist who discovered that all atoms contain negative particles.

Thomson

(*ii*) State one property of the nucleus as discovered by Rutherford.

dense / small / positively charged

(*iii*) Give the term used for the fixed paths described in Bohr's model of the atom.

energy levels ***[accept shells]*** **(8 + 4 + 2)**

(*b*) Consider atoms of the element carbon. Not all carbon atoms are identical.

(*i*) Name the two different types of subatomic particles found in the nuclei of all carbon atoms.

protons **(3)**

neutrons **(3)**

(*ii*) Explain why all carbon atoms have an atomic number of 6.

6 / same number of protons **(6)**

(*iii*) Show the arrangement of the electrons in a carbon atom.

2 / $1s^2$

4 / $2s^2$, $2p^2$ **(4 + 2)**

(*iv*) Why are all carbon atoms electrically neutral?

equal / same number of protons and electrons **(6)**

(*c*) (*i*) What term is used to describe atoms of the same element that have different mass numbers?

isotope

(*ii*) In terms of subatomic particles, explain why carbon atoms can have different mass numbers, i.e. 12, 13 or 14.

different numbers of neutrons in the nucleus **(9 + 3)**

6. The chemical formulae of six hydrocarbons are listed below.

The list includes three alkanes, one alkene, one alkyne and one aromatic hydrocarbon.

CH_4	C_2H_2	C_3H_6
C_4H_{10}	C_5H_{12}	C_6H_6

(*a*) Explain the term hydrocarbon.

compound containing carbon and hydrogen (only) **(5)**

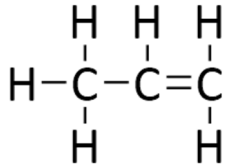
(*b*) (*i*) From the list above identify two alkanes.

CH_4 / C_4H_{10} / C_5H_{12} ***[any two]***

(*ii*) From the list above identify one aromatic compound.

C_6H_6

(*iii*) Draw the molecular structure of C_3H_6 including all atoms and bonds.



(*iv*) What is the systematic IUPAC name for the hydrocarbon C_3H_6?

propene **(9 + 6 + 2 + 2 + 2)**

(*c*) (*i*) State one major use for the gaseous hydrocarbon C_2H_2.

welding / cutting

When C_2H_2 is bubbled through a solution of bromine (Br_2), as shown in the diagram, the orange-coloured solution decolourises.

(*ii*) What information does this give about the nature of the bonding in a molecule of C_2H_2?

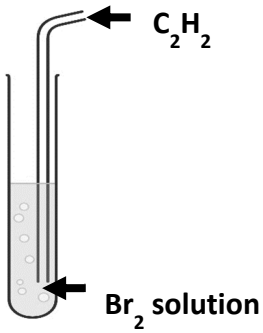
double or triple bond / unsaturated **(9 + 3)**

(*d*) Copy, complete and balance the following chemical equation: $CH_4 + O_2 \rightarrow$

CO_2 **(5)**

H_2O **(5)**

balanced correctly **(2)**



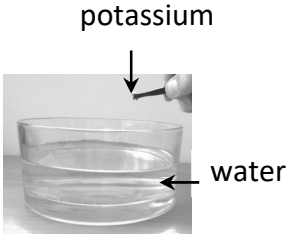
7. (*a*) Define (*i*) an acid, (*ii*) a base.

(*i*) gives H^+ (hydrogen ions) in aqueous solution / H^+ donor **(4)**

(*ii*) give OH^- (hydroxide ions) in aqueous solution / H^+ acceptor **(4)**

(*b*) A tiny piece of potassium metal is added to water.

The potassium reacts vigorously with the water to produce soluble potassium hydroxide and bubbles of hydrogen gas.



The reaction is described by the following word equation:

potassium + water $\rightarrow$ potassium hydroxide + hydrogen gas

(*i*) Replace the words in the word equation above with chemical formulae.

$K + H_2O \rightarrow KOH + H_2$ **(4 × 1)**

(*ii*) Balance your equation from (*i*).

$2K + 2H_2O \rightarrow 2KOH + H_2$ **(2)**

(*iii*) Describe how the solution of potassium hydroxide formed could be tested to show that it was basic.

named indicator / pH meter

correct matching colour change / pH reading **(9 + 3)**

(*c*) (*i*) Define pH.

$-\log_{10}$

$[H^+]$

(*ii*) State the expected pH of a solution that is described as neutral.

7

(*iii*) Calculate the pH of a **HCl** solution of concentration 0.1 M.

$-\log_{10}(0.1)$

1

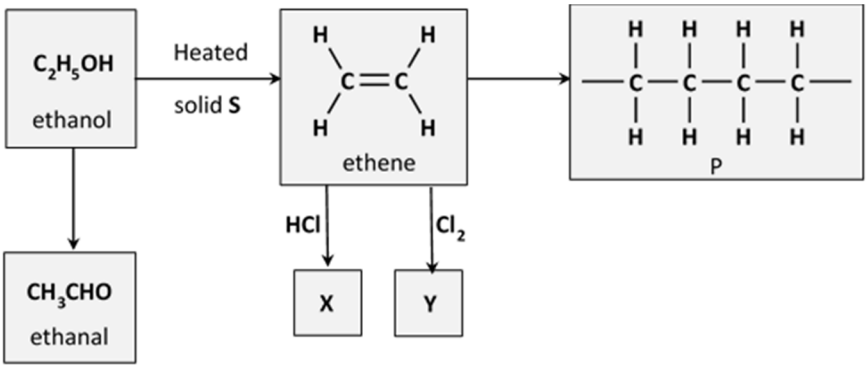
The pH of the water in an aquarium was adjusted from 6.3 to 7.0 by adding a suitable quantity of a 'pH up' solution.

(*iv*) Is the 'pH up' solution acidic or basic? Give a reason for your answer.

basic

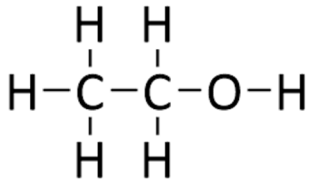
it increases the pH **(8 + 6 + 2 + 2 + 2 + 2 + 2)**

8. The reaction scheme below shows some of the reactions of ethene.



(*a*) (*i*) Is the geometry around the carbon atoms in a molecule of ethene planar or tetrahedral?
planar **(3)**

(*ii*) Draw the structure of a molecule of ethanol, showing all the atoms and bonds.



(6)

(*iii*) Name polymer P, two repeating units of which are shown in the reaction scheme.
polyethene **(6)**

(*iv*) Identify a carbonyl compound from the reaction scheme.
ethanal / CH_3CHO **(3)**

(*b*) (*i*) When ethanol vapour is passed over a heated white solid S it is converted to ethene. Identify S.
aluminium oxide / Al_2O_3 **(6)**

(*ii*) Classify this conversion of ethanol to ethene as an acid-base reaction, a substitution reaction or an elimination reaction.
elimination **(6)**

(*c*) Addition reactions may be used to convert ethene to compound X and to compound Y.

(*i*) Identify compound X, which is produced when HCl is added to ethene.
chloroethane / C_2H_5Cl **(6)**

(*ii*) Identify compound Y, which is produced when Cl_2 is added to ethene.
1,2 dichloroethane / $C_2H_4Cl_2$ ***[allow dichloroethane]*** **(6)**

(*d*) The reaction scheme shows that ethanol can be converted into ethanal by a redox reaction.

(*i*) Is ethanol oxidised or reduced during this conversion?
oxidised

(*ii*) Identify a suitable reagent that could be used to carry out this conversion.
acidified potassium manganate(VII) / Fehling's solution **(6 + 2)**

9. (*a*) Define (*i*) oxidation, (*ii*) reduction, in terms of electron transfer.

(*i*) **loss of electrons** **(4)**

(*ii*) **gain of electrons** **(4)**

(*b*) When a piece of zinc metal is placed into a solution of copper(II) sulfate the redox reaction that occurs is described by the following balanced chemical half equations:

$$Cu^{2+}_{(aq)} + 2e^- \rightarrow Cu_{(s)}$$

$$Zn_{(s)} \rightarrow Zn^{2+}_{(aq)} + 2e^-$$

The overall displacement reaction that occurs is described by the following equation:

$$CuSO_{4(aq)} + Zn_{(s)} \rightarrow Cu_{(s)} + ZnSO_{4(aq)}$$

(*i*) Classify the copper half equation as an oxidation or a reduction.

reduction **(3)**

(*ii*) Identify the reducing agent in the overall reaction.

Zn / Zinc **(3)**

(*iii*) Describe one observation made when zinc reacts with copper(II) sulfate.

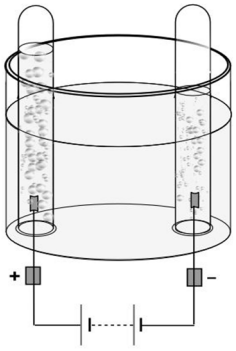
copper / brown / black precipitate forms / blue colour of solution fades **(6)**

(*iv*) Is zinc below or above copper in the electrochemical series? Give a reason for your answer.

above **(3)**

it displaces / reduces the copper **(6)**

(*c*) Water can be split into its elements by electrolysis using <u>inert</u> electrodes.
The electrolyte is water, acidified with a few drops of sulfuric acid.
The electrodes are connected to the positive and negative terminals of a direct current power supply. When the circuit is switched on, bubbles of gas form at both electrodes.
During the electrolysis the volume of gas collected at the negative electrode is twice the volume of the gas collected at the positive electrode.



(*i*) What is meant by the underlined term?

chemically inactive / not reactive **(6)**

(*ii*) Suggest a suitable material that can be used as inert electrodes.

graphite / platinum **(3)**

(*iii*) Why must a few drops of acid be added to the water before starting the electrolysis?

improve conductivity **(3)**

(*iv*) Identify the two gases collected during the electrolysis of water.

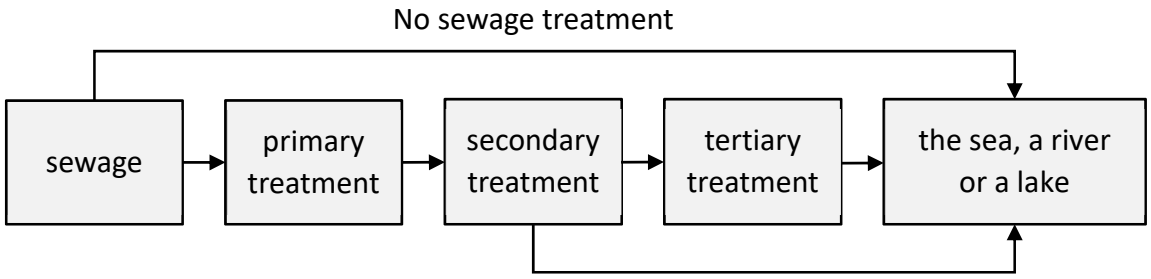
hydrogen **(3)**

oxygen **(3)**

(*v*) Which of these gases is formed by reduction at the negative electrode?

hydrogen **(3)**

10 (*a*) The flow chart below shows the stages of sewage treatment.



(*i*) Settling tanks are used at different stages of sewage treatment. What happens in a settling tank?
removes insoluble solids / heavier solids to sink to the bottom

(*ii*) At what stage of sewage treatment is the organic biodegradable matter broken down by bacteria?
secondary

(*iii*) What is the specific purpose of the tertiary stage of sewage treatment?
to remove nitrates / phosphates

(*iv*) Describe a problem that arises when sewage is not treated before discharging it into the sea, a river or a lake.
eutrophication / death of plants and animals ***[allow pollution]*** **(9 + 7 + 7 + 2)**

(*b*) Matter is composed of three different types of tiny particles: atoms, molecules and ions.

(*i*) Name the three states of matter.
solid
liquid
gas

(*ii*) What is meant by the term ion?
charge particle

(*iii*) Classify helium as an atom, a molecule or an ion.
atom

(*iv*) Name two states of matter that exist at the melting point of a substance.
solid
liquid

(*v*) In which state of matter do the particles vibrate around fixed positions?
solid **(9 + 3 + 3 + 2 + 2 + 2 + 2 + 2)**

(*c*) Boron carbide (**B_4C**) is an extremely hard ceramic used in some padlocks. It is made by heating boron trioxide (**B_2O_3**) with carbon in an electric furnace.

In a reaction, 140 g of **B_2O_3** was heated in the presence of excess carbon to give **B_4C** and carbon monoxide (**CO**) according to the following balanced chemical equation:

$$2B_2O_3 + 7C \rightarrow B_4C + 6CO$$

The relative molecular mass (M_r) of **B_2O_3** is 70.

(*i*) Calculate the number of moles of **B_2O_3** in 140 g.

$\frac{140}{70}$ = 2 (moles)

(*ii*) Calculate the number of moles of **B_4C** produced.

2 ÷ 2 = 1 (mole)

(*iii*) Calculate the mass of **B_4C** produced.

M_r = 56

56 × 1 = 56 (g)

(*iv*) Calculate the number of moles of **CO** produced.

2 × 3 = 6 (moles)

(*v*) Calculate the volume (in litres) of this quantity of **CO** gas, measured at s.t.p.

6 × 22.4 = 134.4 (L) **(9 + 8 + 2 + 2 + 2 + 2)**

11. (*a*)

beryllium (Be)	fluorine (F)	gallium (Ga)	hydrogen (H)	lithium (Li)	neon (Ne)	Selinium (Se)

Write in your answer book the omitted element corresponding to each of the numbers 1 to 7.

The first element of the table is __1__. The element sodium is in the same group as __2__. The alkaline earth metals make up Group 2 and include the element __3__. The existence and properties of the element __4__ in the same group as aluminium and the same period as __5__ was predicted by Mendeleev before its actual discovery in 1875. Group 18 of the modern table contains the noble gases, including __6__ ; there were no noble gases in Mendeleev's original table. The photograph shows Clarice Phelps, recognised as one of the scientists whose work led to the discovery in 2009 of element 117, a halogen now called tennessine, that is in the same group as __7__

1 = hydrogen / H
2 = lithium / Li
3 = beryllium / Be
4 = gallium / Ga
5 = Selinium / Se
6 = neon / Ne
7 = fluorine / F **(9 + 6 + 2 + 2 + 2 + 2 + 2)**

(*b*) Study the substances below and answer the questions that follow:

Name	Formula	Bonding
Sodium chloride	NaCl	ionic
Hydrogen chloride	HCl	polar covalent
Nitrogen	N_2	covalent

(*i*) Which of the substances above is formed by the complete transfer of electrons between atoms?
sodium chloride / NaCl

(*ii*) Identify which of these substances is formed by equal sharing of pairs of electrons by atoms.
nitrogen / N_2

(*iii*) Which of these substances is formed by unequal sharing of pairs of electrons by atoms?
hydrogen chloride / HCl

(*iv*) Identify the substance you would expect to be the most soluble in a non-polar solvent such as cyclohexane.
nitrogen / N_2

(*v*) Identify the substance you would expect to be highly soluble in water.
sodium chloride / hydrogen chloride

(*vi*) Draw a dot and cross diagram to show the arrangement of the valence shell electrons in any one of these substances.

(9 + 6 + 4 + 2 + 2 + 2)

(*c*) Hydrogen (H_2) and iodine (I_2) form a chemical equilibrium when mixed together in a sealed container. The reaction may be described by the following balanced chemical equation:

$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

(*i*) What is meant by chemical equilibrium?

rate of forward reaction equals rate of reverse reaction

(*ii*) Write the equilibrium constant (K_c) expression for this reaction.

(K_c) = $\frac{[\mathbf{HI}]^2}{[\mathbf{H_2}][\mathbf{I_2}]}$

[–2 if K_c is inverted but otherwise correct]

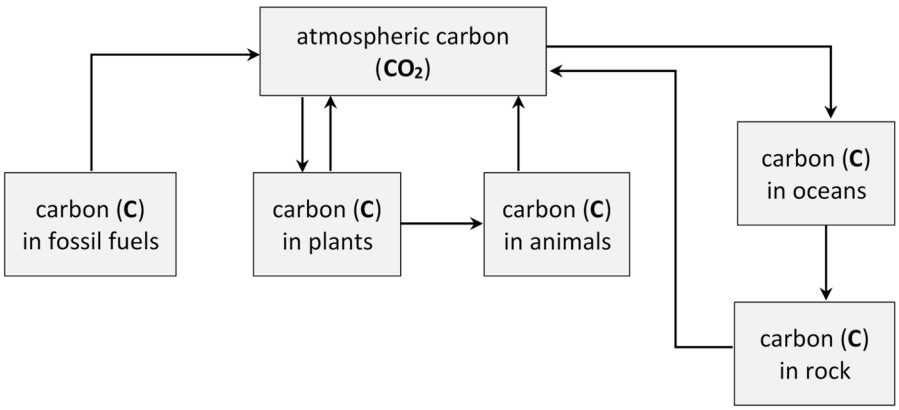
(*iii*) State Le Châtelier's principle.

systems at equilibrium oppose applied stresses

(*iv*) Use Le Châtelier's principle to predict the effect on the yield of HI of adding more iodine. Give a reason for your answer.
increase
reaction moves in forward direction to reduce concentration of iodine

(9 + 6 + 6 + 2 + 2)

A Consider the simplified version of the Earth's carbon cycle shown in the diagram.



(*i*) Explain how the carbon in fossil fuels becomes **CO_2** in the atmosphere.
release carbon dioxide when combusted

(*ii*) Identify one natural process by which **CO_2** is removed from the atmosphere.
photosynthesis / dissolving in oceans

(*iii*) Name the environmental effect which results in heat from the sun being trapped in Earth's atmosphere by gases including CO_2.
(enhanced) greenhouse effect

(*iv*) Give a reason why the Earth's atmospheric CO_2 concentrations have been increasing over the last 200 years.
burning fossil fuels / deforestation

(*v*) Suggest one way in which humans could change their behaviour to help reduce atmospheric CO_2 concentrations.
carbon capture / renewable energy sources / reforestation *etc*. **(9 + 9 + 3 + 2 + 2)**

B Households are encouraged to recycle metal food and drinks cans. These cans are usually made either of steel coated with a thin layer of tin, or of aluminium.

(*i*) Aluminium cans resist corrosion. What is corrosion of a metal?
reaction of metal with air /oxygen

(*ii*) Explain how coating iron with a protective layer of paint (or of another metal) protects the iron from corrosion.
prevents reaction with oxygen /water

(*iii*) Identify the metal used when iron is galvanised.
zinc / Zn

(*iv*) State an advantage of recycling aluminium in preference to extracting more of the metal from its ores.
extraction is costly / extraction uses a lot of energy

(*v*) Name a process involved in the manufacture of steel.
electric arc process / smelting **(9 + 9 + 3 + 2 + 2)**