Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2023

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.

Introduction

In considering the marking scheme, the following should be noted.

1. In many cases only key phrases are given which contain the information and ideas that must appear in the candidate's answer in order to merit the assigned marks.

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

3. The detail required in any answer is determined by the context and the manner in which the question is asked, and by the number of marks assigned to the answer in the examination paper and, in any instance, therefore, may vary from year to year.

4. The bold text indicates the essential points required in the candidate's answer. A double solidus (//) separates points for which separate marks are allocated in a part of the question. Words, expressions or statements separated by a solidus (/) are alternatives which are equally acceptable for a particular point. A word or phrase in bold, given in brackets, is an acceptable alternative to the preceding word or phrase. Note, however, that words, expressions or phrases must be correctly used in context and not contradicted, and, where there is incorrect use of terminology or contradiction, the marks may not be awarded. Cancellation may apply when a candidate gives a list of correct and incorrect answers.

5. In general, names and formulas of elements and compounds are equally acceptable except in cases where either the name or the formula is specifically asked for in the question. However, in some cases where the name is asked for, the formula may be accepted as an alternative.

6. There is a deduction of one mark for each arithmetical slip made by a candidate in a calculation. 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 addition error. If the addition of atomic masses is not shown, the candidate loses the marks for an incorrect M_r.

7. 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 obtain more than 75% of the total marks.

Candidates are required to answer any EIGHT questions.

All questions carry equal marks (50).

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

Annotations used in marking Chemistry 2023

For a fully correct response examiners may award one total mark, e.g. six marks or a number of partial marks, e.g. 2 marks, 3 marks, 1 mark that add to the same total.

For partially correct responses examiners should place the apropriate marks near the correct part of the response and/or use 0 marks to indicate the part of the answer that is incorrect or insufficient.

Examiners should annotate fully incorrect responses or responses of no merit with a 0 mark.

Colours of annotations may vary.

Annotation	Meaning
 n	n marks awarded
	Mathematical slip error or other penalty as per scheme
	No marks awarded. Answer incorrect or insufficient
	Reverse order
	Surplus answer or part of answer
	Blank page or part of page
	Cancellation / contradiction
	Part of answer of significance
	Incorrect charge, subscript, etc
	Key word, phrase omitted
	Correct – e.g. used where item attempted more than once
	Incorrect

QUESTION 1

(*a*) IDENTIFY: (*i*) **H_2O / water**

IDENTIFY: (*ii*) **calcium** di**carbide / CaC_2 / calcium (II) carbide** (8 + 3)

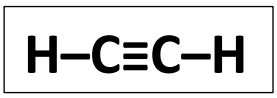
[Allow carbide]

[Allow any order of responses.]

(*b*) (*i*) EXPLAIN: **insoluble** in water **/ doesn't dissolve** in water

(*ii*) WHY: **impure / contain air (oxygen, nitrogen) / do not contain** enough (or any) **ethyne** (7 + 2)

(*c*) (*i*) DRAW:



(*ii*) EXPLAIN: contains **multiple (triple** or **double**) carbon-carbon **bond / can add hydrogen**

(*iii*) WHAT: **brown (red, orange, yellow)** colour **//**
disappears (decolourises, fades) (6 + 6 + 3 + 3)

(*d*) (*i*) DESCRIBE: **put lighting taper** (wooden **splint**) **into** test-tube of **ethyne (gas) / apply a flame**

(*ii*) DESCRIBE: **bright (yellow, luminous, sooty, smoky)** flame **/ smuts (soot,** black **smoke)**

(*iii*) GIVE: **oxyacetylene flame** / oxy-acetylene **metal cutting /**
oxy-acetylene **welding** (flame) / carbide **lamp**
[Allow ripening bananas or fruit.]
(7 + 3 + 2)

QUESTION 2

(*a*) EXPLAIN: **known concentration** (5)

(*b*) (*i*) IDENTIFY: A: wash **bottle //**
B: **pipette** (2 × 3)
[Take order of responses unless answers clearly labelled.]

(*ii*) GIVE: **rinse pipette (B) / rinse burette / rinse conical flask /**
wash down sides of conical flask during titration /
so all added substances can **react** (6)

(*iii*) DESCRIBE: **rinsed with deionised (distilled, pure) water //**
rinse with **sodium carbonate (Na_2CO_3) solution /**
rinse with **solution pipette (it) will hold** (2 × 2)
[Allow (2) for correct responses in reverse order.]
[Allow (2) for rinse with sodium carbonate (Na_2CO_3) only.]

(*iv*) WHY: **difficult to swirl contents / contents more easily spilled /**
contents lost by splashing / spatters (droplets) from burette **escape /**
sloping sides better / straight sides less suitable (don't keep contents inside)
(5)

(*c*) (*i*) NAME: **methyl orange / methyl red** (3)

(*ii*) STATE: **yellow (orange) //**
to pink (red, peach) (2 × 3)
[*If there is no response for (i) marks can be awarded for correct colours in (ii).*]
[6 *Marks may be given for correct colours for a named unsuitable indicator, e.g. litmus, blue to red*.] [*Allow (3) for correct colours reversed (and matching a named indicator where one is named.)]*
[*(9) marks only available for correct indicator linked to correct colours in correct order*.]

(*d*) (*i*) WHAT: **to find approximate titre (volume required for neutralisation, result) /**
to allow accurate titre (volume required for neutralisation, result) to be
found more easily (quickly) (3)

(*ii*) CALCULATE: **22.45** cm^3 (3)

(22.5 + 22.4) ÷ 2 = **22.45** cm^3 (3)

(*iii*) CALCULATE: **0.1**11 mol l^{-1} HCl (9)

$\frac{\mathbf{22.45} \times \boldsymbol{M}}{\mathbf{2}}$ = (3)

$\frac{\mathbf{25.0} \times \mathbf{0.05}}{\mathbf{1}}$ (3)

3 marks may be awarded for formula if **no other marks** awarded above.

M = 0.**1**11 mol l^{-1} HCl (3)

or

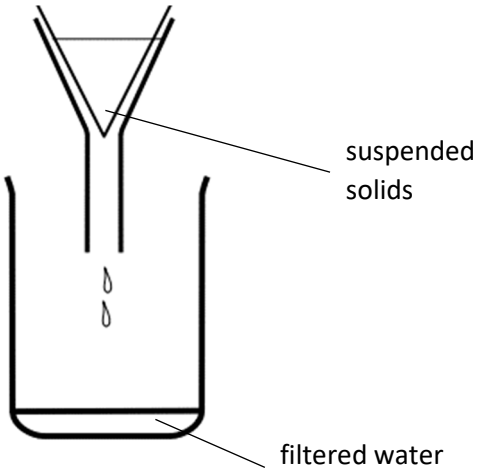
$\frac{25.0 \times 0.05}{1000}$ = **1.25 × 10^{-3}** moles Na_2CO_3 (3)

$1.25 \times 10^{-3} \times 2$ = **2.50 × 10^{-3}** moles HCl (3)

$M = \frac{2.50 \times 10^{-3} \times 1000}{22.45}$ = 0.**1**11 mol l^{-1} HCl (3)

QUESTION 3

(*a*) (*i*) DESCRIBE: **filtration diagram with at least one label //**
known (stated) volume water **/** find **mass** dried filter paper **/**
weigh dried filter paper (8 + 3)



(*ii*) DESCRIBE: **evaporate** to dryness **//**
known (stated) volume //
filtered water //
in beaker (evaporating basin, etc) //
find **mass** residue **/ weigh** residue **//**
calculate the concentration (6 + 3)

EXPRESS: (*iii*) 0**.08** g l^{-1} (3)

0**.04 × 2** = 0**.08** g l^{-1} (3)

EXPRESS: (*iv*) **80** mg l^{-1} (p.p.m.) (3)

0**.08 × 1000** = **80** mg l^{-1} (p.p.m.) (3)

(*b*) (*i*) IDENTIFY: **chloride (Cl^-) //**
nitrate (NO_3^-)

(*ii*) NAME: **silver nitrate**

(*iii*) WHAT: **white //**
precipitate (solid)
[Allow (3) for dissolves in ammonia if no other marks awarded.]

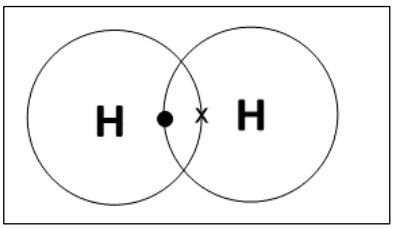
(*iv*) WHAT: **brown**

(*v*) WHAT: **yellow** (6 + [6 × 3])
[accept **orange**]

QUESTION 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 for which the highest marks are awarded.

(*a*) WHAT: **isotopes** (6)

(*b*) DRAW:  or  (6)

(*c*) WRITE: **protons // two** (2 × 3)

(*d*) STATE: **product** of pressure and volume **constant (*pV* constant, $p_1V_1 = p_2V_2$) /**
pressure **inversely proportional** to volume **($p \propto 1/V$) /**
volume **inversely proportional** to pressure **($V \propto 1/p$) /** (6)
[Accept indirectly proportional]

(*e*) DEFINE: **relative (measure of) attraction / number expressing (giving) attraction //**
for shared electrons / for shared pair / for electrons in a covalent **bond** (2 × 3)

(*f*) FIND: 0.**4**08 g (6)

M_r = (10 × 12) + 16 = **136**	(3)
0.003 × 136 = 0.**4**08 g	(3)

(*g*) WHAT: **heat / energy (**kilogram **calorific) //**
of combustion / content (value) of fuel (food) (2 × 3)

(*h*) EXPLAIN: **heat (energy) released / negative ΔH** (6)

(*i*) NAME: **sludge / biosolids (slurry, manure)** (6)

(*j*) FIND: **60**% (6)

M_r = 48 + (2 × 16) = **80**	(3)
% Ti = $\frac{48}{80} \times 100$ = **60**%	(3)

(*k*) (*i*) NAME: Liebig (reflux) **condenser**
(*ii*) WHAT: **reflux**ing (4 + 2)

(*l*) **A** WHY: **poison / toxic / greenhouse gas (global warning)** (6)
or
B WHY: **to make it conducting / to allow ions to move / solid cannot conduct /**
ions not free to move in solid (6)

QUESTION 5

(*a*) (*i*) DEFINE: **cannot be broken down into simpler substance(s)** chemically **/**
composed of atoms with same number of protons (atomic number)

(*ii*) HOW: listed elements according to increasing atomic **weight (**atomic **mass) /**
properties varying periodically / in columns (groups) of similar properties

(*iii*) GIVE: **elements listed** according to increasing **atomic weight in original table /**
elements listed according to increasing **atomic number in modern table /**
gaps for undiscovered elements **in original table /**
noble gases not in original table /
more elements in modern table /
transition elements in separate block in modern table (9 + 6 + 3)
[Allow opposite statements to those listed above.]

(*b*) (*i*) DEFINE: **number** of **protons** in an atom **/**
number of **electrons** in a neutral atom (6)

(*ii*) WHAT: **3** (3)

(*iii*) HOW MANY: **4** (3)

WRITE: (*iv*) Li: **2, 1 / $1s^2\ 2s^1$** (3)

WRITE: (*v*) Ne: **2, 8 / $1s^2\ 2s^2\ 2p^6$ / $1s^2 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2$** (3)

(*vi*) WHICH: **lithium** more reactive (3)

EXPLAIN: **losing an electron makes lithium more stable /**
lithium can satisfy octet rule by losing an electron /
neon is stable /
neon satisfies octet rule (3)

(*c*) (*i*) GIVE: **additional (one more, extra, three) shell in sodium / outer electron of sodium in third shell** and **outer electron of lithium in second shell /**
lithium has fewer (only **two) shells /**
more screening (shielding) of nucleus by electrons in inner shells **in sodium /**
less screening (shielding) of nucleus by electrons in inner shells **in lithium**

(*ii*) EXPLAIN: effective **nuclear charge (number of protons) increasing** (6 + 2)

QUESTION 6

(*a*) (*i*) IDENTIFY: **agriculture (cattle, sheep, pigs, slurry) / coal mining / landfill / decomposition of organic matter (biodigesters) / etc.**

(*ii*) WRITE: **CH_4**

(*iii*) EXPLAIN: contain **hydrogen (H) //**
and **carbon (C)** only (6 + 4 + 2 + 2)

(*b*) (*i*) GIVE: **fuel / cooking / heating / generating electricity / source of hydrogen / etc.**

(*ii*) WHICH: **alkanes**

(*iii*) DESCRIBE: **tetrahedral**

(*iv*) WHY: **safety /** in case of **leaks / to detect** the gas **/ to give** the gas **a smell /**
because the gas **is odourless** (8 + 6 + 2 + 2)

(*v*) WHAT: **propane //**
butane (2 × 3)

(*c*) (*i*) NAME: **methylbenzene / phenylmethane / toluene**

(*ii*) STATE: **not aromatic / aliphatic //**
REASON: **it doesn't have a benzene ring /**
not a planar **cyclic** compound with delocalised pi electrons (8 + 2 + 2)

QUESTION 7

(*a*) DEFINE: (*i*) gives **hydrogen (hydronium) ions (H^+, H_3O^+) in aqueous solution (water) / proton (hydrogen ion, H^+) donor / electron pair acceptor**

DEFINE: (*ii*) gives **hydroxide (hydroxyl) ions (OH^-) in aqueous solution (water) / proton (hydrogen ion, H^+) acceptor / electron pair donor** (5 + 3)

(*b*) (*i*) COPY & COMPLETE: **water** (3)

(*ii*) REPLACE & BALANCE: **$HCl + KOH \rightarrow KCl + H_2O$**

two correct molecular formulae: (2 + 2)
full balanced equation: (2)

(*c*) (*i*) GIVE: **sodium hydroxide (NaOH) / ammonia (NH_3, NH_4OH) / magnesium hydroxide ($Mg(OH)_2$) / calcium hydroxide ($Ca(OH)_2$) / sodium carbonate (Na_2CO_3) / sodium hydrogencarbonate ($NaHCO_3$) / etc.** (6)

(*ii*) WHAT: *any base:* **cleaning drains / dissolving grease / cleaning ovens / cleaning floors (surfaces) /**
magnesium hydroxide, calcium hydroxide, sodium carbonate, sodium hydrogencarbonate: **toiletries / toothpaste / indigestion** remedies **/**
sodium carbonate, sodium hydrogencarbonate: **baking** soda (powder) **/ raising agent /**
calcium hydroxide: **neutralising acidic soil /**
etc. ANY ONE: (3)

(*d*) (*i*) DEFINE: pH = **–log / negative log // $[H^+]$ / $[H_3O^+]$ / hydrogen ion concentration** (2 × 3)
[Accept non-square brackets.]

(*ii*) CALCULATE: **2.4** (6)

log 0.**004 / –log** 0.**004**	(3)
pH = – log 0.004 = **2.4**	(3)

[No rounding or incorrect rounding = slip error.]
[Negative final answer is not a slip error.]

(*iii*) HOW: **universal indicator** paper or solution **/ pH meter**
[Deduct 2 marks if indicator / named indicator used instead of universal indicator / pH meter.]

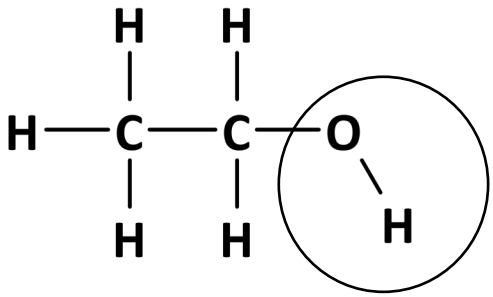
(*iv*) WHAT: **7** (9 + 3)

QUESTION 8

(*a*) (*i*) GIVE: X: **ethanol (ethyl alcohol) //**
Y: **ethanal (ethyl aldehyde) //**
Z: **ethanoic acid** (5 + 2 + 2)
[Take order of responses unless answers clearly labelled.]

(*ii*) GIVE: **flavouring / preserving / acidity regulator / pickling** (3)
[Allow **vinegar**.]

(*b*) (*i*) DRAW:



[O–H bond not required]

CIRCLE: **OH circled**

(*ii*) EXPLAIN: OH **polar / hydrogen (H) bonding** between water and ethanol **/**
strong **intermolecular forces** between water and ethanol **/**
strong **attraction between the water and ethanol** molecules (8 + 2 + 2)

(*c*) (*i*) IDENTIFY: **alumina (aluminium oxide, Al_2O_3)**

(*ii*) IDENTIFY: acidified **$KMnO_4$ (MnO_4^-,** potassium **manganate(VII),** potassium **permanganate /**
acidified **Na_2CrO_4** (**K_2CrO_4, CrO_4^{2-}, chromate) /**
acidified **$Na_2Cr_2O_7$** (**K_2 Cr_2O_7, $Cr_2O_7^{2-}$, dichromate)**

(*iii*) DESCRIBE: **blue** solution **to //**
brick **red / precipitate** (6 + [3 × 3])

(*d*) (*i*) CLASSIFY: **addition**

(*ii*) IDENTIFY: **X (ethanol, C_2H_5OH) //**
ethene (C_2H_4) / accept **ethanal (Y, CH_3CHO)** (7 + 2 + 2)

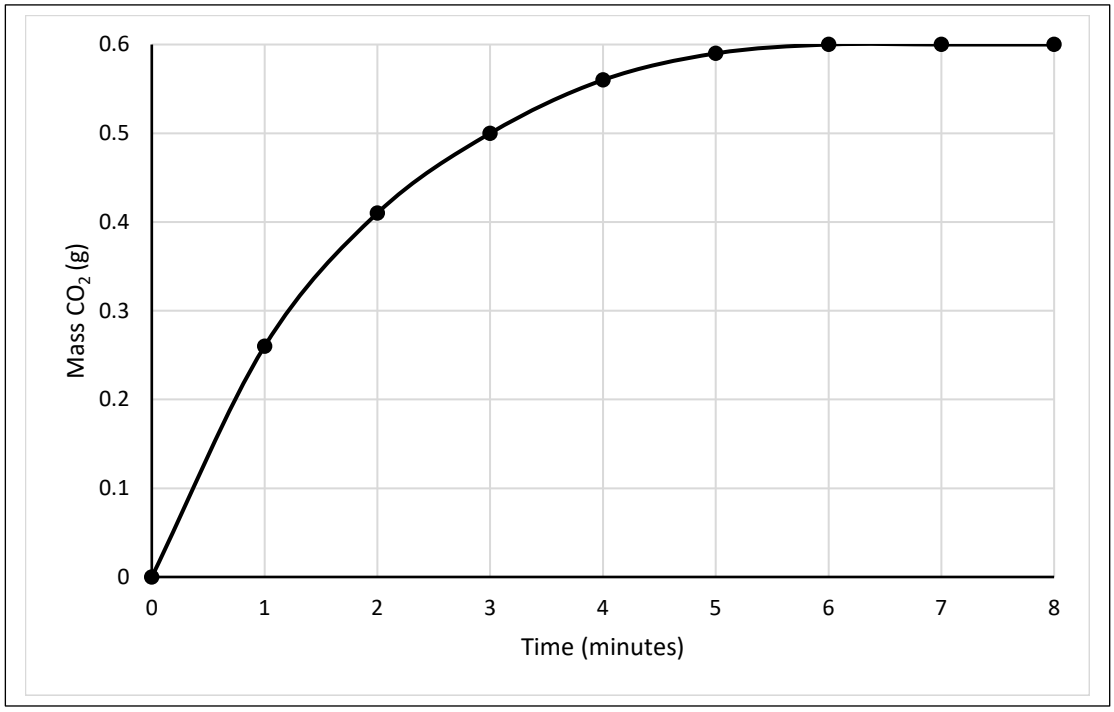
QUESTION 9

(*a*) WHAT: **change in concentration** of a reactant or product **//**
per (in) unit time (4 + 2)
[Accept **speed** of reaction for (3) marks.]

(*b*) (*i*) PLOT: **axis correctly labelled g (mass, *m*)** (3)
axis correctly labelled minute (min, time, *t*) (3)
axes correctly scaled (3)
7 points other than (0, 0) correctly plotted on graph paper (3)
curve drawn through (very close to) points and origin (3)
[Points joined by straight lines not acceptable.]
[Axes reversed acceptable.]

(*ii*) DOES: **decreases** (3)

GIVE: **calcium carbonate (HCl, reagents) get**s **used up /**
concentration of HCl decreases / rate proportional to concentration /
slope of tangent to **graph decreases** (3)



(*c*) FIND: (*i*) **5.5 – 6**.0 minute

FIND: (*ii*) **1.1** – **1.3** minute

FIND: (*iii*) 0**.41 –** 0**.49** g CO_2 (6 + 6 + 3)

(*d*) HOW: **faster (bigger)** rate
JUSTIFY: **greater surface area / more** $CaCO_3$ **particles** exposed to HCl solution **/**
more collisions between reactants per second **/ etc.** (6 + 2)

QUESTION 10

(*a*) (*i*) HOW: **loses //**
one (an) **electron** (2 × 3)

(*ii*) HOW: **gains //**
one (an) **electron** (2 × 3)

(*iii*) HOW MANY: **6** (3)

(*iv*) WHAT: **electrostatic attraction (force) / opposite charge**d ions **attract / ionic bonds** (3)

(*v*) GIVE: **high melting point (m.p.) / high boiling point (b.p.) / soluble in water / hard / brittle /** can **conduct electricity** when molten (dissolved)
ANY TWO: (4 + 3)

(*b*) DEFINE: (*i*) **loss** of electrons
(*ii*) **gain** of electrons
[Take order of question unless clearly labelled.]

(*iii*) HOW MANY: **2**

(*iv*) WHICH: **Mg (magnesium)**

(*v*) STATE: **blue** colour of solution **disappears (fades) /**
magnesium (Mg) dissolves (appears to **disappear) /**
brown (red, black) flecks of **metal (copper, solid)** appear

(*vi*) WOULD: **no**

EXPLAIN: **magnesium (Mg) higher up electrochemical series (more easily oxidized, more** re**active)** than copper (Cu) **/**
copper (Cu) lower down electrochemical series (less easily oxidized, less re**active)** than magnesium (Mg) **/**
copper (Cu) cannot displace (replace) magnesium (Mg) from (in) its salts /
magnesium ions (Mg^{2+}) cannot be replaced (displaced) by copper ions (Cu^{2+}) / not reversible
(6 + 4 + [5 × 3])

(*c*) (*i*) WHAT: **alters rate of (speeds up, slows, down) a reaction // without being used up / is chemically unchanged** (4 + 3)

(*ii*) FIND: **3.6 × 10^{23}** atoms Mg (3)

1 mole = 6 × 10^{23} atoms

0.6 × 6 × 10^{23} = **3.6 × 10^{23}** atoms Mg (3)

(*iii*) HOW MANY: 0**.2** moles nitrogen gas (3)

Mg : N_2 = 3 : 1

$\Rightarrow$ 0.6 ÷ 3 = 0**.2** moles N_2 (3)

(*iv*) CALCULATE: **4.48** litres N_2 (3)

0.2 × 22.4 = **4.48** litres N_2 (3)

(*v*) WHAT: M_r Mg_3N_2 = **100** (3)

(3 × 24 + 2 × 14) = **100** (3)

(*vi*) FIND: **20** g Mg_3N_2 (6)

0**.2** moles Mg_3N_2 (3)

100 × 0.2 = **20** g Mg_3N_2 (3)

QUESTION 11

(*a*) (*i*) WHAT: **coagulation (clumping together, sticking together) //**
of small (light, suspended) particles / giving larger (heavier, denser) particles /
giving particles that sink (settle) / giving flocs (2 × 3)

(*ii*) WHAT: **sand (gravel)** (3)

(*iii*) WHY: **to remove (kill) pathogens (microorganisms, bacteria, germs) /**
to prevent water-borne disease (illness) /
to avoid water **becoming re-contaminated after purification** (3)

HOW: **chlorination / adding ozone / with uv light** (3)

(*iv*) WHY: **to prevent tooth decay / good for the teeth / strengthens enamel** (3)

(*v*) WHAT: **corrosion of pipes / damage to teeth (bones) / illness** (3)

(*vi*) WHAT: **hard (not soft) / from limestone area / doesn't lather** well with soap /
alkaline (basic) (4)

(*b*) (*i*) EXPLAIN: *reversible reaction:*
products change back into reactants /
simultaneous **forward and reverse reactions /**
reaction does not go to completion (goes both ways) (3)

chemical equilibrium:
forward and reverse reactions **//**
have equal rates

or

concentrations of reactants and products **//**
are constant (2 × 2)

(*ii*) WRITE: $K_c = \frac{[\mathbf{NH_3}]^2}{[\mathbf{N_2}][\mathbf{H_2}]^3}$ (6)
[numerator correct (3) and denominator correct (3); inverted (3)]
[Accept round brackets.]

(*iii*) STATE: **stress (change** of conditions**) applied to a system** in equilibrium **//**
results in **reaction to relieve (reduce, absorb, counteract)** the stress (2 × 3)

(*iv*) WHY: **safety (**to avoid **danger)** / **cost** (3)

(*v*) WHY: **to speed up reaction / too slow at low temperatures /**
more cost effective / catalyst more efficient (3)

(*c*) WRITE: A **kerosene //**

B **low //**

C **high //**

D **refinery gas //**

E **small //**

F **residue //**

G **large** (7 + 7 + 3 + [4 × 2])

(*d*)

A

(*i*) STATE: **breathing (respiration)** gas for patients (divers, firefighters, pilots, etc.) **/**
steelmaking / to support combustion of ethyne, in rockets etc. **/**
welding / reduce river pollution / etc. (4)

(*ii*) STATE: **packaging** of food **/ flushing (purging)** tanks of flammable substances **/**
freezing (preserving) food (biological specimens, sperm, semen) **/**
remove unwanted skin **cells / treat** skin **cancer (wart**s**, verruca**e**) / etc.** (3)

(*iii*) HOW: **triple (strong) bond / N≡N / high bond energy / non-polar** (3)

(*iv*) HOW: about **four-fifths (78 – 80%)** (6)
[Allow (3) for most abundant or very abundant.]

(*v*) EXPLAIN: the **conversion of** atmospheric **nitrogen //**
to compounds that can be used (absorbed) by plants /
to more reactive compounds / to nitrates / to NO_2 (2 × 3)

(*vi*) EXPLAIN: addition to (presence in) to atmosphere (air) of **toxins (contaminants, harmful substances)**
or
addition to (presence in) atmosphere (air) of **substances that cannot be removed (broken down) easily** (3)

or

B

(*i*) STATE: **metal**lic **/ hard (strong) / shiny (lustrous) / malleable / ductile /**
good catalysts / form coloured compounds / good conductor of heat /
good conductor of electricity / variable valency (oxidation state) ANY TWO: (2 × 3)

(*ii*) WHAT: **reaction** of metal **with air (oxygen,water, chemicals in environment) /**
formation of metal **oxide / damage caused by chemicals** (6)
[Allow (3) for **rusting**.]

(*iii*) SUGGEST: **iron (Fe) highest up electrochemical series (most easily oxidised, more** re**active) /**
iron oxide flakes off / oxides of copper and lead adhere, gold not oxidised /
copper and lead have protective oxide layers, gold not oxidised (3)

(*iv*) HOW: **keeps air (oxygen) away** from the iron **/ covers the iron with zinc /**
zinc (Zn, galvanised layer) corrodes first (more easily than iron) /
zinc (Zn) higher up electrochemical series (more easily oxidised) (6)
[Allow (3) for any reference to zinc / protective layer.]

(*v*) WHAT: **alloy of iron / mixture of iron and carbon (other elements, other metals)** (4)