

Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2018

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.
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 obtained more than 75% of the total marks.

Candidates are required to answer eight questions.

All questions carry equal marks (50).

Section A

At least two questions must be answered from this section.

Section B

At least five questions must be answered from this section.

Eight items to be answered in **Question 4**. Six marks 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.

Note that candidates who attempt **Question 10** are required to answer two of the parts (a), (b) and (c) and candidates who attempt **Question 11** are required to answer two of the parts (a), (b) and (c) where candidates who answer part (c) may choose **A** or **B**.



Coimisiún na Scrúduithe Stáit

400@10%

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 ghnóthaíonn 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 ghnáthráta 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

Section A

At least two questions must be answered from this section.

QUESTION 1

- (a) IDENTIFY: **aluminium oxide / Al₂O₃** (5)
- (b) (i) DESCRIBE: **colourless**
[‘Clear’ acceptable.]
- (ii) WHY: **impure / contain air (impurities) / displaced air (oxygen) / mixture of air (oxygen) and ethene**
(6 + 3)
- (c) (i) WHAT: **water from trough goes (sucked) back up delivery tube / vacuum produced / vacuum in apparatus / gas (air) inside contracts / water takes place of gas (air) inside**
- (ii) WHY: **cold water could cause test-tube (apparatus, glass) to crack (shatter, explode) releasing flammable gas into flame**
- (iii) WHAT: **break vacuum by removing end of delivery tube from water / break vacuum by loosening stopper / remove (reduce) heat from under test-tube only after letting air in (breaking vacuum)**
(6 + 3 + 3)
- (d) (i) IDENTIFY: **bromine (Br₂) solution (water) / acidified potassium permanganate (H⁺/KMnO₄)** (3)
- (ii) WHAT: **red (brown, orange, yellow) /purple (pink) // to colourless / decolourised (colour fades)**
[Reagent and reagent colour linked.] (2 × 3)
- (e) (i) HOW: **unstopper and quickly insert lighting taper (splint, match) into test tube / bring lighting taper (splint, match) into contact with ethene** (6)
[Allow (5) for ‘insert taper (splint, match)’.]
- (ii) DESCRIBE: **bright {yellow, luminous, fairly clean, slightly (not very) sooty (smoky)}** (3)
- (iii) COPY, COMPLETE, BALANCE: **C₂H₄ + 3O₂ → 2CO₂ + 2H₂O**
PRODUCTS: (3), BALANCING: (3)

QUESTION 2

(a) NAME: A: **volumetric flask**
 B: **burette**
 C: **pipette** (5 + 3 + 3)

(b) WHICH: (i) **A / volumetric flask / first / name given for A in (a)**
 (ii) **C / pipette / third / name given for C in (a)**
 (iii) **B / burette / second / name given for B in (a)** (6 + 2 + 1)

(c) IDENTIFY: **burette / B / pipette / C / name given for B or C in (a)** (3)

(d) EXPLAIN: solution of exactly **known concentration (molarity)** (6)

(e) (i) NAME: **methyl orange** (3)

(ii) WHAT: **yellow (orange) to // red (pink, peach)** (2 × 3)

[Marks may be given for correct colours of an incorrect indicator.
 Allow (3) for correct colours reversed (and matching a named indicator).
 (9) marks only available for correct indicator and correct colours in correct order.]

(f) CALCULATE: $(22.7 + 22.6) \div 2 = \mathbf{22.65 \text{ cm}^3}$ (3)

0.11 moles l⁻¹ (9)

$\frac{25 \times 0.05}{1} \quad (3)$	/	$\frac{25 \times 0.05}{1000} = \mathbf{0.00125 \text{ moles Na}_2\text{CO}_3} \quad (3)$
$= \frac{22.65 \times M}{2} \quad (3)$		$\Rightarrow \mathbf{0.0025 \text{ moles HCl in } 22.65 \text{ cm}^3} \quad (3)$
$M = \mathbf{0.11 \text{ moles l}^{-1}} \quad (3)$		$\frac{\mathbf{0.0025 \times 1000}}{22.65} \Rightarrow M = \mathbf{0.11 \text{ moles l}^{-1}} \quad (3)$

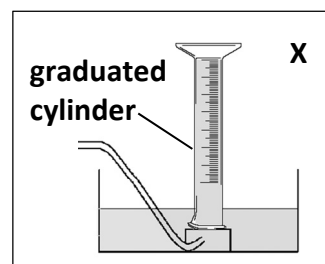
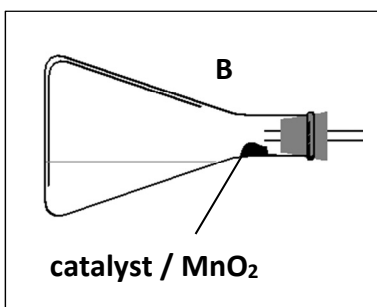
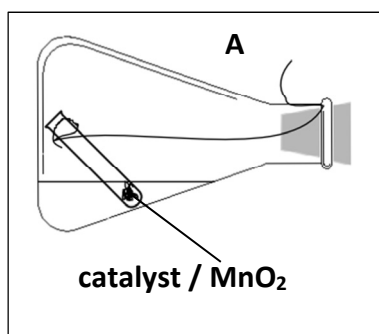
[Treat answer given as 0.1 M as a slip.]

[Allow (3) for $\frac{V_1 M_1}{n_1} = \frac{V_2 M_2}{n_2}$ if last (9) not awarded.]

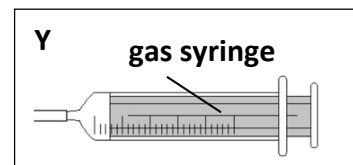
QUESTION 3

- (a) NAME: **graduated cylinder / graduated dropper / pipette / syringe / burette** (6)
- (b) DESCRIBE: **black (brown, dark) / solid (powder)** (6)
- (c) COPY (i) **neck of flask – B / in small test-tube inside flask – A**
COMPLETE [Catalyst must be labelled.]
(ii) **graduated cylinder (burette) inverted over water – X /**
& LABEL: **graduated gas syringe – Y**
[Label necessary unless graduations clearly marked.]

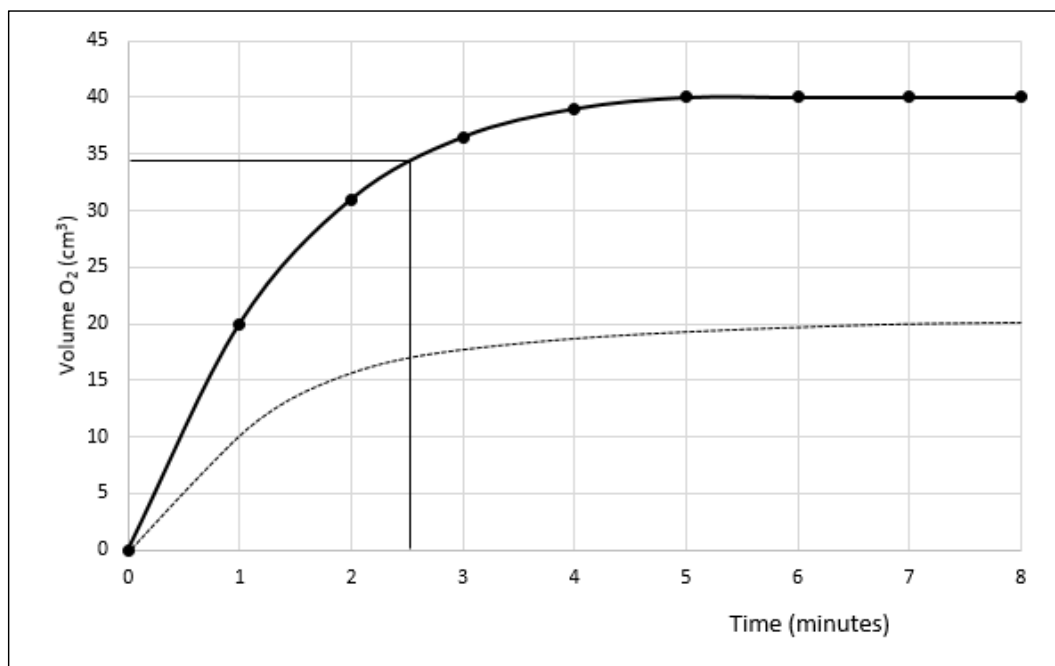
(6 + 3)



[Allow flask upright; allow gas collection proceeding.]



(d) (i) PLOT:



axes correctly labelled with unit or quantity (3)
[Deduct (3) for axes reversed.]

axes correctly scaled (3)
eight points correctly plotted (on candidate's scale) (6)
[Allow (3) for 6 points correctly plotted.]

smooth CURVE correctly drawn through points and (0, 0) (3)
[Straight line(s) unacceptable for curve.]

(ii) WHY: **hydrogen peroxide (reactant, reagent) used up / less hydrogen peroxide (reactant, reagent) / concentration hydrogen peroxide (reactant, reagent) less / rate proportional to concentration** (3)

(iii) USE: **34 cm³ [33 to 35 cm³]** (6)

(iv) SKETCH: **less steep as per dotted line on graph // half volume O₂ produced as per dotted line on graph** (3 + 2)

SECTION B

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) GIVE: **no noble gases / some elements undiscovered / fewer elements / no separate *d*-block (transition element block) / elements arranged in order of atomic mass (weight) / gaps for undiscovered elements** (6)

(b) GIVE: **Rh / Pt / Pd** (6)
[Allow names.]

(c) IDENTIFY: X: **hydrogen (H₂) //**
Y: **oxygen (O₂)** (2 × 3)
[Allow (3) for reverse order (unless labelled correctly).][Allow (3) for H and O.]

(d) WRITE: **H₂ + Cl₂ → 2HCl / ½ H₂ + ½ Cl₂ → HCl**
[Allow (3) for HCl.]

REACTANTS & PRODUCT: (3), BALANCING: (3)

(e) CALCULATE: **0.5** (6)

$\text{pH} = -\log_{10} [\text{H}^+] / \text{pH} = -\log_{10} [\text{H}_3\text{O}^+] / \text{pH} = -\log_{10} 0.3 / 0.3 \text{ moles H}^+$	(3)
$\text{pH} = -\log 0.3 = 0.5$	(3)

[Allow (3) max for $-\log_{10} 0.15 / 0.8$.]

(f) IS: **exothermic** (3)

GIVE: **ΔH negative / methanol (CH₃OH) is a fuel / combustion reactions exothermic (give out heat)** (3)
[IS and GIVE not linked.]

(g) WRITE: **CH₂O** (6)
[Allow (3) for ratio 1:2:1.]

(h) WHAT: **settlement / settling / screening / sedimentation / mechanical (physical) separation (purification) / removal of suspended solids / large particles removed by grit channels** (6)

(i) EXPRESS: **220 ppm (mg l⁻¹)** (6)

$0.11 \times 2 = 0.22 \text{ g per litre}$	(3)	/	$0.11 \times 1000 = 110 \text{ mg per } 500 \text{ cm}^3$	(3)
$0.22 \times 1000 = 220 \text{ ppm (mg l}^{-1}\text{)}$	(3)		$110 \times 2 = 220 \text{ ppm (mg l}^{-1}\text{)}$	(3)

(j) IDENTIFY: **beta-decay (beta-radiation) / β -decay (β -radiation)** (6)
[Allow (3) for 'radioactivity' or 'beta'.][Allow (3) for 'beta-particle' or ' β -particle'.]

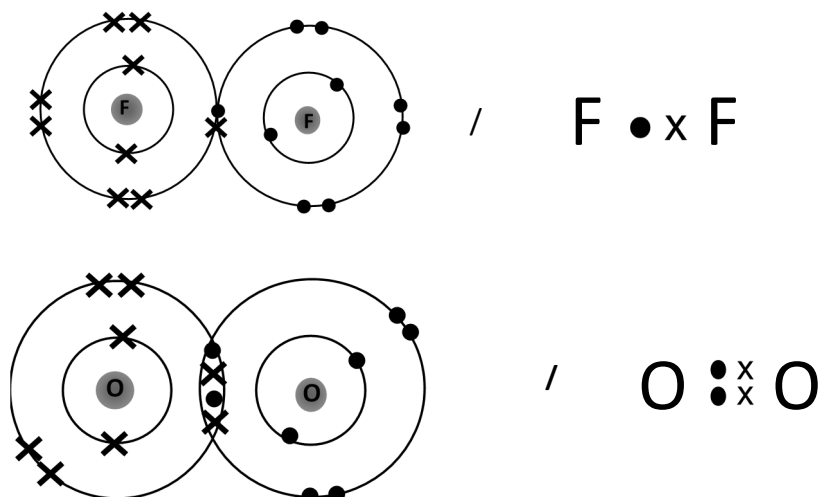
(k) A NAME: **buckminsterfullerene / bucky ball / fullerene** (6)
or

B WHY: **unreactive (inert, stable) / doesn't corrode / can be pressurized / minimum maintenance / strong (doesn't break) / easily cleaned (disinfected) / high performance** (6)

QUESTION 5

- (a) WHY: argon has **eight electrons in outer shell** /
 argon has a **stable electron arrangement (configuration)** /
 argon is a **noble (inert) gas** /
 argon in **Group 18 (Group 8, Group VIII, Group 0)** (5)
 [Allow 'argon doesn't need any more electrons'.]
 [Allow (3) for 'argon has a full outer shell'.]

- (b) DRAW:



Fluorine : **one shared pair and incorrect lone pairs (-3)**

Oxygen: **two shared pairs and incorrect lone pairs (-3)**

[Inner electrons need not be shown.][Lone pairs need not be shown.]

[Take drawings in order of question unless answered in reverse order and both molecules clearly labelled.][All dots or all crosses acceptable.]

- (c) DEFINE: **relative (measure of) attraction / number expressing (giving) attraction // for shared electrons (pair) / for electrons in a covalent bond** (2 × 3)
- (d) USE: (i) **C** (5)
high melting (boiling) point / high m.p. (b.p.) / 730 / 1380 (2)
- (ii) **B** (5)
boiling point (b.p.) below room temperature (about 20 °C) / -196 /
electronegativity difference (e.n.) 0.96 / 0.4 < 0.96 < 1.7 (2)
- (iii) **A** (5)
low melting (boiling) point / low m.p. (b.p.) / -114 / -85
electronegativity difference (e.n.) zero (2)
- (e) WHAT: **v-shaped / v-planar / bent** (6)
 [Allow correct shape given in a diagram.]

QUESTION 6

- (a) WHAT: **hydrocarbon(s)** (5)
- (b) GIVE: A: **methane**
C: **propene**
D: **ethyne** (3 × 3)
- (c) TO WHICH: (i) **alkane(s)** (3)
(ii) **alkyne(s)** (3)
- (d) (i) WHICH: **E / benzene**
(ii) WRITE: **C₆H₆**
(iii) WHY: **carcinogenic / toxic / harmful / poisonous / dangerous**
[Do not allow 'benzene expensive'.] (6 + 3 + 3)
- (e) WHICH: **D / ethyne** (6)
[Accept name given in (b).]
- (f) WHICH: **A / methane**
WHY: **global warming / climate change / greenhouse effect / greenhouse gas / rising sea levels / etc**
[Do not allow 'damages ozone layer' or 'causes acid rain'.] (9 + 3)

QUESTION 7

- (a) (i) WHAT: water containing dissolved **calcium (magnesium) ions** /
water containing dissolved **Ca²⁺ (Mg²⁺)** /
water that **doesn't form a lather** easily **with soap** (6)
- (ii) WHAT: **temporary** (3)
- NAME OR FORMULA: **calcium hydrogencarbonate / calcium bicarbonate / (Ca(HCO₃)₂) /
magnesium hydrogencarbonate / magnesium bicarbonate / (Mg(HCO₃)₂)** (3)
- (iii) IDENTIFY: **pipes blocked / limescale (fur) on (in) pipes (elements, kettles, boilers) /
water heating costs higher / boilers less efficient / uses too much soap /
makes scum with soap / difficult to make a lather with soap** (6)
- (iv) GIVE: **tastes nice (good, better) / contains Ca²⁺ / good for bones (teeth, health) /
good for brewing (distilling, tanning) industry** (6)
- (b) (i) WHAT: **flocculation**
- (ii) GIVE: **filtration / description of filtration / removal of suspended particles**
- (iii) WHAT: **to kill microorganisms (bacteria) that could cause illness / to kill pathogens
(germs) / to sterilize / to avoid water becoming re-contaminated after
purification**
[Allow 'to clean water'.]
- (iv) WHY: **to prevent tooth decay / NaF good for the teeth / strengthens enamel**
[Allow 'fluoridation' or 'strengths teeth'.]
- (v) UNDER WHAT: **water too acidic / pH too low / to increase pH / to prevent pipe corrosion**
(8 + (2 × 6) + (2 × 3))

QUESTION 8

- (a) NAME: W: **ethene //**
X: **ethanal //**
Y: **ethanoic acid** ((2 × 6) + 3)
[Take names in order of question unless names clearly linked to letters W, X and Y.]
- (b) DRAW: (6)
- $$\begin{array}{c} \text{H} \quad \text{H} \\ | \quad | \\ \text{H}-\text{C}-\text{C}-\text{OH} \\ | \quad | \\ \text{H} \quad \text{H} \end{array} \quad / \text{CH}_3\text{CH}_2\text{OH} / \text{C}_2\text{H}_5\text{OH}$$
- (c) WHICH: **W / ethene** (6)
[Accept name given in (a).]
- (d) CLASSIFY: (i) **addition / oxidation //**
(ii) **oxidation** (6 + 3)
- (e) DESCRIBE: **blue** changes //
to brick **red (orange)** precipitate (6 + 3)
[Allow (3) for colours reversed.]
- or*
- brick red (orange) //**
precipitate formed (6 + 3)
- (f) GIVE: **flavouring / preservative / pickling** (5)
[Allow 'vinegar'.]

QUESTION 9

- (a) DEFINE: (i) **loss of electrons //**
(ii) **gain of electrons** (2 × 6)
- (b) (i) WHICH: **potassium (K)** (6)
(ii) WHICH: **chlorine (Cl₂, Cl)** (6)
- (c) (i) DESCRIBE: (6 + 5 + 1)

Method 1	Method 2	Method 3	
clean a platinum (nichrome) wire* (rod, probe) in concentrated hydrochloric acid (HCl)	soak wood (splint, stick) overnight in water / use damp (wet) wood (splint, stick)	prepare a solution of the salt in water and ethanol (propanol)	(6)
dip rod in salt and hold salt in (over) hot (blue) part of flame (Bunsen)	dip splint (stick) in salt and hold salt in (over) hot (blue) part of flame (Bunsen)	spray solution onto (into) hot (blue) part of flame (Bunsen)	(5)
observe colour of flame	observe colour of flame	observe colour of flame	(1)

*[Allow 'inoculating loop', or 'spatula' for 'platinum wire'.]

[Clear labelled diagram for some or all points acceptable.]

- (ii) WHAT: **lilac (purple, violet)** (3)
- (d) WHAT: **white / cloudy / milkiness / precipitate** (6)
- (e) GIVE: potassium has **lower electronegativity** / potassium has **greater atomic radius** / potassium *is bigger* / potassium has **lower ionisation energy** / potassium **loses its outer electron more easily** / potassium's **outer electron farther from nucleus** / **alkali metals more reactive down group** / potassium is **farther down group** (5)
[Allow equivalent opposite statements specifying sodium.]

QUESTION 10: Answer any **two** of the parts (a), (b) and (c).

- (a) WRITE:
- 1 H⁺ //
 - 2 OH⁻ //
 - 3 salt / water //
 - 4 water / salt //
 - 5 neutralisation
 - 6 HCl (hydrochloric acid) //
 - 7 NaOH (sodium hydroxide)
- (7 + (6 × 3))

[Same answer for 3 and 4 are unacceptable.]

- (b) DEFINE:
- (i) **number of protons** in an atom of an element /
[Allow 'gives element's position in periodic table of elements' or
'number of electrons in a neutral atom'.] (3)
- (ii) **number of protons and neutrons** in an atom of an element (3)
- (iii) atoms of the **same element** / atoms with the **same atomic number** /
atoms with **same number of protons** //
that have different atomic masses / **that have different numbers of neutrons**
(2 × 3)
[Number, quantity, amount protons or neutrons need only be mentioned once.]
- (iv) WHAT: **17** (3)
- (v) HOW MANY: **2, 8, 7** (4)
[Allow correct Bohr diagram for (3); allow s, p configuration (3).]
- (vi) WHAT: **35.45 / 35.5** (3)
- (vii) WHY: weighted **average** of the mass numbers of the isotopes as they occur
naturally / chlorine has **isotopes** (3)

- (c) (i) COPY & COMPLETE: $(14 \times 2) + 16 = \mathbf{44}$ // $\mathbf{6.0 \times 10^{23}}$ // $\mathbf{22.4}$ (3 × 3)
- (ii) WHAT: $14 + (1 \times 4) + 14 + (16 \times 3) = \mathbf{80}$ (3)
- (iii) HOW MANY: $\mathbf{0.4}$ moles H₂O / $\mathbf{2/5}$ moles H₂O (6)
- | |
|--|
| $n = \frac{m}{A_r} = \frac{16}{80} = \mathbf{0.2}$ moles NH ₄ NO ₃ (3) |
| $\mathbf{0.2}$ moles \Rightarrow $\mathbf{0.4}$ moles H ₂ O (3) |
- WHAT: $\mathbf{4.48}$ litres N₂O (7)
- | |
|--|
| $\mathbf{0.2}$ moles N ₂ O (3) |
| $\mathbf{0.2} \times 22.4 = \mathbf{4.48}$ litres N ₂ O (4) |

QUESTION 11: Answer any **two** of the parts (a), (b) and (c).

(a) NAME: **solid, liquid, gas** (5)

WHAT: (i) **ion is a charged atom (group of atoms) / atom has no charge and ion has a charge / atom has an equal numbers of protons and electrons and ion has an unequal numbers of protons and electrons** (3)

(ii) **molecule is two or more neutral atoms bonded together / atom is the smallest part of an element and molecule is the smallest part of a substance that can exist independently** (3)

GIVE: **ink (dye, coloured crystal) in water (liquid) / smoke in air /scent from opened perfume bottle (gas tap, chemical with an odour, named chemical with strong odour) fills room / HCl and NH₃ at ends of glass tube / etc** (6)
[Allow (3) for description of diffusion.]

SUPPLY: 1: **pressure (volume) //**
2. **volume (pressure) //** (3 + 3 + 2)
3: **temperature**
[Same answer for 1 and 2 are unacceptable.]

(b) (i) EXPLAIN: state where **forward and reverse reactions //**
have equal rates (4 + 3)

(ii) WRITE: $K_c = \frac{[\text{Cl}_2][\text{SO}_2]}{[\text{SO}_2\text{Cl}_2]}$ (6)
[Allow (3) for expression inverted.]
[Square brackets not essential.]

(iii) PREDICT: **loses colour / becomes paler / becomes less green**
[Accept 'colourless'.]

(iv) GIVE: **change temperature / heat (cool)**
[Allow 'add (remove, change concentration of) a chemical in equilibrium mixture'.]

(9 + 3)

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

A

HOW: (i) a **metal is hard(er) / plastics are soft(er) //**
(ii) a **metal is shiny (shinier) / metal has more sheen (lustre) /**
plastics are often shiny (6 + 3)

WHAT: **electrical insulation / it doesn't conduct electricity / flexible** (6)

GIVE: **lighter / no corrosion / noise reduction / cheaper / better insulated /**
no corrosion / more energy efficient (6)
[Allow 'flexible', 'easier to join'.]

WHAT: (iii) **malleability (malleable) //**
(iv) **ductility (ductile)** (2 × 2)

B

(i) STATE: **NH₃ / HNO₃ / MgO** (3)

(ii) WHAT: NH₃: make **fertilizer (urea, ammonium nitrate, ammonium sulfate, nitric acid,**
nylon)
HNO₃: **fertilizer (ammonium nitrate, calcium ammonium nitrate, CAN, explosive)**
manufacture
MgO: **refractory / fire brick / lining chimneys (furnaces)** (6)
[Response to WHAT is linked to response to STATE.]

(iii) SELECT: NH₃: **H₂ in natural gas or coal / N₂ in air / river water**
HNO₃: **ammonia / O₂ in air / river water**
MgO: **seawater / limestone / river water** ANY TWO FROM ONE LINE: (2 × 3)
[Response to SELECT is linked to response to STATE.]

(iv) SELECT: **transport network: to transport feedstock (workers, product)**
third-level institute: to supply educated workforce
power supply: to provide energy for furnaces (kilns, pumps)
telecommunications: to allow communications with suppliers
(market, customers, workforce) ANY EXPLANATION: (6)
[Response to SELECT is linked to response to STATE.]

(v) HOW: **emissions**
NH₃: **scrubbers (filters, electrostatic precipitation) to remove dust (ammonia) /**
HNO₃: **scrubbers (filters, electrostatic precipitation) to remove oxides of /**
nitrogen (ammonia)
MgO: **scrubbers (filters, electrostatic precipitation) to remove dust /**
waste effluent
NH₃: **remove ammonia or nitrates from waste water before release from plant /**
adjust pH of water
HNO₃: **remove ammonia or nitrates from waste water before release from plant /**
adjust pH of water
MgO: **remove suspended solids from water / adjust pH of water** (4)
[Response to HOW is linked to response to STATE.]

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