Mock Exam 2

CHEMISTRY **9701**

Paper 2 AS Structured Questions

MARK SCHEME

Maximum Mark: 72

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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1

(a)

TWO correct responses from ✓
- Different numbers of neutrons
- Different (atomic) masses/mass numbers
- Different **physical** properties
  Physical required

1 | AO1.1

IGNORE heavier/lighter

DO NOT ALLOW different **relative atomic** masses
BUT ALLOW different relative **isotopic** masses

DO NOT ALLOW different **chemical** properties
OR different properties

IGNORE different abundancies

(b)

Element	Mass number	Protons	Neutrons	Electrons	Charge	
Fe	54	26	28	26	0	✓
Se	80	34	46	36	2–	✓

Mark by row

2 | AO1.2 ×2

THREE responses for each mark
Easiest to check element first

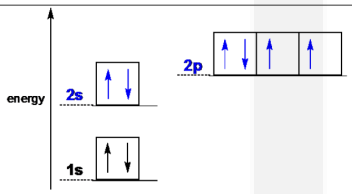
ALLOW Se^{2-}
ALLOW names for elements

(c)

Sub-shells labels
2s (single box) **AND** 2p (3 boxes) ✓

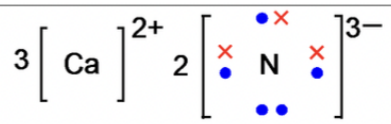
Electrons as arrows
unpaired electrons in 3 boxes: ↑↓ ↑ ↑
AND
Paired electrons in single box: ↑↓ ✓

2 | AO1.1 | AO1.2



ALLOW single headed arrows, e.g. 1

(d) **(i)**



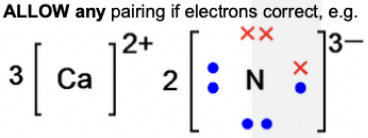
Ca shown with either 0 or 8 electrons
AND
N shown with 8 electrons with 5 dots and 3 crosses (or vice versa) ✓

3 Ca **AND** 2 N **AND** correct charges on ions,
i.e. $3Ca^{2+}$ $2N^{3-}$ ✓

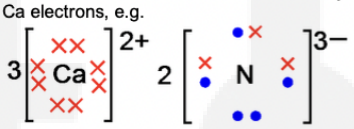
Circles **OR** Brackets **NOT** required

2 | AO2.5 | AO1.2

CARE:
ALLOW any pairing if electrons correct, e.g.

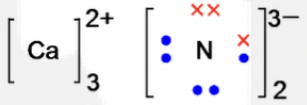


IF 8 electrons shown around Ca,
'extra' 3 electrons around N must match symbol for Ca electrons, e.g.



IGNORE inner shells

ALLOW drawing with 3 Ca^{2+} and 2 N^{3-}
e.g.



(d) **(ii)**

$Ca_3N_2 + 6H_2O \rightarrow 3Ca(OH)_2 + 2NH_3$

$Ca(OH)_2$ **OR** NH_3 as product ✓

All species correct **AND** correct balancing ✓

2 | AO2.6 ×2

ALLOW NH_4OH for NH_3

ALLOW $Ca_3N_2 + 8H_2O \rightarrow 3Ca(OH)_2 + 2NH_4OH$

IGNORE other products

Exemplar 1

(ii) Calcium nitride reacts with water to form a solution containing two alkaline compounds.

Write an equation for this reaction.

$Ca_3N_2 + 3H_2O \longrightarrow 2NH_3 + 3CaO$ [2]

Exemplar 2

(ii) Calcium nitride reacts with water to form a solution containing two alkaline compounds.

Write an equation for this reaction.

$Ca(NO_3)_2 + H_2O \longrightarrow Ca(OH)_2 + 2HNO_3$ [2]

Most candidates were given 1 of the 2 available marks for showing the formula of one correct product, $Ca(OH)_2$ or NH_3. The best answers identified both products and were then able to balance the equation. Common errors included 'CaO' as a product and incorrect compounds of nitrogen (see the two responses above). This part discriminated very well.

(e)

'*Dot and cross*' of central N to O OR N ✓ N→O OR N=O N≡N OR N=N OR N=N --- **Rest of '*dot and cross*' diagram correct** ✓ e.g. N≡N→O OR N=N=O	**2**	AO2.5 ×2	**Electrons do NOT need to be shown paired.** **'Dot and cross' of NO_2** **ALLOW** 1st mark for N→O **OR** N=O **DO NOT ALLOW** ions **CARE** For 2nd mark, watch for stray paired **OR** unpaired electrons on central N **ALLOW** 10 electrons around central N atom for 2 marks, i.e.

N_2O is a very unfamiliar molecule for candidates and they found this 'dot and cross' diagram far more difficult than diagram for Ca_3N_2 in 21(d)(i). Information in the question clearly stated that a nitrogen atom is in the centre but many diagrams were drawn with the O atom at the centre. It was also fairly common to see NO_2 rather than N_2O. Candidates found the bonding of the O atom to the central N atom easier than the double or dative covalent bond between the two N atoms. Many candidates included lone pairs on the central N atom despite this resulting in a non-linear molecule. (The question states that the molecule is non-linear). It was common to see an expanded octet with 10 electrons being involved with the central N atom (a triple and double bond). If correct, this was given, reflecting a candidate's knowledge at this stage of the course. Candidates are advised to take great care in showing clear symbols for electrons (dots and crosses or other symbols). Parts of the diagram where a dot and a cross cannot be distinguished cannot be credited. This part discriminated extremely well.

(f)

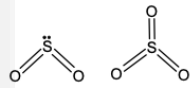
M1 moles of water in 210 mg = mass / mr = 0.210 / 18 = 0.0117 mol ONLY Equal to moles of magnesium hydroxide produced in stage one M2: mass of $Mg(OH)_2$ = 0.0117 x 58.3 = 0.680 g M3: mass of MgO = 3.2 – 0.68 = 2.52 g M4: % of MgO = 2.52/3.2 x 100 = 78.7%	M1 = moles of water M2 = mass of $Mg(OH)_2$ = M1 x 58.3 M3 = subtraction = 3.2 – M2 M4 = answer to M3 x 100/3.2 Alternative correct alternative methods such as M1 = moles of water M2 = mass of $Mg(OH)_2$ = M1 x 58.3 M3 = M2 x 100/3.2 M4 = 100 – M3 M4: Allow 78.7 – 78.8 or 79 %	4

2

(a) $4FeS_2 + 11O_2 \rightarrow 2Fe_2O_3 + 8SO_2$ — 1 1 [2]

(b)

(i)



M1 SO_2 correct M2 SO_3 correct — 1+1 [2]

(ii) 115–120° bent / non-linear — 1
120° trigonal planar — 1 [2]

(c)

(i) Advantage = higher rate — 1
Greater KE / energy / speed / collision frequency / proportion of successful collisions / more particles with E>Ea — 1

Disadvantage – reduced yield / less product — 1

(Forward reaction) **exothermic AND** (hence in accordance with LCP) equilibrium / reaction **shifts left** (to counteract inc T) ora — 1 [4]

(ii) $K_p = \frac{pSO_3^{\ 2}}{pSO_2^{\ 2} \times pO_2}$ — 1 [1]

(iii)

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$
2 2 0
(–1.8) (–0.9)
0.2 1.1 1.80 — 1

$xSO_3 = 1.8/3.1 = 0.581$
$xSO_2 = 0.2/3.1 = 0.065$
$xO_2 = 1.1/3.1 = 0.355$ — 1

$K_p = \frac{0.581^2 \times (2 \times 10^5)^2}{0.065^2 \times (2 \times 10^5)^2 \times 0.355 \times 2 \times 10^5} = 1.13 \times 10^{-3}\ Pa^{-1}$ — 1+1 [5]

(d) (i)

Amount of Nitrogen monoxide = 1.15 mol	Answers to min 2sf	1
Amount of Chlorine = 0.825 mol		1

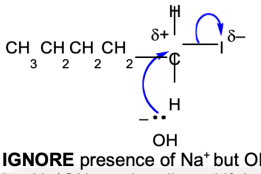
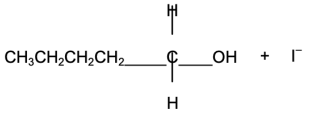
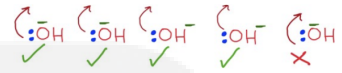
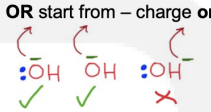
(ii)

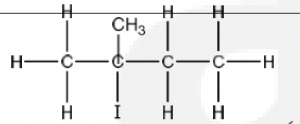
$K_c = \frac{[NOCl]^2}{[NO]^2[Cl_2]}$		1

(iii)

$1.32 \times 10^{-2} = \frac{[NOCl]^2}{\left[\frac{0.85}{0.800}\right]^2 \left[\frac{0.458}{0.800}\right]}$ $[NOCl]^2 = 8.53 \times 10^{-3}\ mol^2dm^{-6}$ $[NOCl] = 0.0924\ mol\ dm^{-3}$ n(NOCl) = 0.0924 x 0.800 = 0.0739 mol (answer to 2sf or more)	M1 = divides mole quantities by 0.800 M2 = evaluates $[NOCl]^2$ M3 = √M2 M4 = M3 x 0.800 (allow ecf on an incorrect volume used in M1) If no division in M1 then max 3 M2 = 4.37×10^{-3} M3 = 0.0661 mol dm^{-3} M4 = 0.0529 mol If Kc upside down then can still score 4 M1 = divides mole quantities by 0.800 M2 = 48.96 M3 = 7.00 mol dm^{-3} M4 = 0.600 mol Incorrect rearrangement loses M2	1 1 1 1 1

3	**(a)**		(Acid) releases H^+ ions/ H^+ donor **AND** (weak acid) partially dissociates/ionises ✓	1	**ALLOW** H^+ **OR** proton **IGNORE** vague responses that do not imply a number, e.g. • poor proton donor **IGNORE** 'doesn't easily dissociate' **IGNORE** 'a strong acid completely dissociates' *Question is about a weak acid*
	(b)	**(i)**	**2** Al(s) + **6** $CH_3COOH(aq) \rightarrow$ **2** $(CH_3COO)_3Al(aq)$ + **3** $H_2(g)$ ✓	1	**ALLOW** multiples, e.g. Al(s) + **3**$CH_3COOH(aq) \rightarrow (CH_3COO)_3Al(aq)$ + **1½**$H_2(g)$
		(ii)	Element oxidised: aluminium/Al 0 to +3 ✓ Element reduced: hydrogen/H +1 to 0 ✓	2	**ALLOW** 3+ for +3 and 1+ for +1 **ALLOW** H_2 for hydrogen **ALLOW** 1 mark for elements **AND** all oxidation numbers correct, but H in oxidised line and Al in reduced line '+' is required in +3 and +1 oxidation numbers **IGNORE** numbers around equation *(treat as rough working)*
	(c)	**(i)**	**FIRST CHECK THE ANSWER ON THE ANSWER LINE** **If answer = 2.21 (mol dm^{-3}) award 4 marks** --- **TITRATION** **M1** $n(Ba(OH)_2)$ in 25.0 cm^3 = = **1.125 × 10^{-3}** (mol) ✓ **M2** $n(CH_3COOH)$ in 25.45 cm^3 **diluted** vinegar = **2** × 1.125 × 10^{-3} = **2.25 × 10^{-3}** (mol) ✓ --- **SCALING** **ALLOW ECF** from $n(CH_3COOH)$ **M3** $[CH_3COOH]$ in **diluted** vinegar $= \frac{2.25 \times 10^{-3} \times 1000}{25.45}$ = **0.0884** (mol dm^{-3}) ✓ Calculator: 0.0884086 **M4** $[CH_3COOH]$ in **original** vinegar $= \frac{0.0884 \times 250}{10.0}$ = **2.21** (mol dm^{-3}) ✓	4	**FULL ANNOTATIONS MUST BE USED** --- **ALLOW 3 SF** or more correctly rounded throughout Apply **ECF** where appropriate **ALLOW ECF** from $n(Ba(OH)_2)$ --- **ALTERNATIVE APPROACHES FOR M3 AND M4:** --- **M3** $n(CH_3COOH)$ in 25.45 cm^3 **original** vinegar $= \frac{2.25 \times 10^{-3} \times 250}{10.0}$ = 0.05625 (mol) ✓ **M4** $[CH_3COOH]$ in **original** vinegar $= \frac{0.05625 \times 1000}{25.45}$ = 2.21 (mol dm^{-3}) ✓ --- **M3** $n(CH_3COOH)$ in 250 cm^3 **diluted** vinegar $= \frac{2.25 \times 10^{-3} \times 250}{25.45}$ = 0.0221 (mol) ✓ **M4** $[CH_3COOH]$ in **original** vinegar $= 0.0221 \times \frac{1000}{250} \times \frac{250}{10.0}$ = 2.21 (mol dm^{-3}) ✓
	(c)	**(ii)**	***Assumption***: Vinegar contains (ethanoic acid and) **no other acids** ✓ ***Prediction***: Expermental result is greater than conc of CH_3COOH **OR** conc of CH_3COOH is less than experimental result ✓	2	For credit, the response **must** refer to other **acids** **IGNORE** impurities, solution is pure, etc **ONLY award the 'prediction' mark if 'assumption' mark is correct**
			Total	10	

4	(a)	(i)	Curly arrow from HO^- to carbon atom of C–I bond ✓ Dipole shown on C–I bond, $C^{\delta+}$ and $I^{\delta-}$ **AND** curly arrow from C–I bond to I atom ✓  **IGNORE** presence of Na^+ but OH^- needed i.e. Na^+OH^- can be allowed if the criteria are met --- Correct organic product **AND** I^- ✓  **IGNORE** presence of Na^+ but I^- needed i.e. Na^+I^- can be allowed BUT NaI does not show I^-	**3**	AO2.5 ×3	**ANNOTATE ANSWER WITH TICKS AND CROSSES** **NOTE**: curly arrows can be straight, snake-like, etc. but **NOT** double headed or half headed arrows **1st curly arrow** must • go to the C of C–I **AND** • start from, **OR** be traced back to **any point across width** of lone pair on O of OH^-  • **OR** start from – charge **on O** of ^-OH ion  *(Lone pair **NOT** needed if curly arrow shown from O^-)* **2nd curly arrow** must start from, **OR** be traced back to, **any part of** C–I bond and go to I 
		(ii)	**Time** for **precipitate** to appear ✓	**1**	AO3.3	Time **AND** precipitate required *Question asks for measurement*

	(a)	(iii)	C–I bond is weaker (than C–Br bond) **OR** C–I bond has a lower bond enthalpy (than C–Br bond) ✓ Carbon – halogen **bond breaks** ✓	**2**	AO3.2	**For 2 marks,** **ALLOW** C–I is broken more easily (than C–Br) as the bond is weaker There must be a **comparison** between C–Br and C–I bonds
	(b)	(i)	Molecular mass ✓	**1**	AO1.1	**IGNORE** 'relative' **IGNORE** 'molecular ion' alone, answer must relate to **mass** **ALLOW** M_r / molar mass
		(ii)	**Y**: $CH_3CH_2CH_2CH_2CH_2^+$ ✓ **Z**: $CH_3CH_2CH_2^+$ ✓ ***If positive charge is missing** but the structures of **Y AND Z** are correct, award one mark*	**2**	AO3.2 ×2	**FOR ONE MARK** **ALLOW** $C_5H_{11}^+$ **AND** $C_3H_7^+$ **ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous
	(c)	(i)	 ✓	**1**	AO1.1	**ALLOW** any combination of skeletal **OR** structural **OR** displayed formula as long as unambiguous
		(ii)	**Similarity** Both have a peak at (m/z =) 198 (X) **OR** 71 (Y) **OR** 29 ✓ **Difference** 2-iodo-2-methylbutane has **no** peak at (m/z =) 43 (Z) ✓	**2**	AO3.2 ×2	**ALLOW** same molecular ion peak / M_r **IGNORE** statements where no specific ion peak is suggested e.g. "different ion peaks"
			Total	**12**		

5 (a) $C_4H_8O_2$ (1) [1]

(b)

$HCO_2CH_2CH_2CH_3$ **W**	$HCO_2CH(CH_3)_2$ **X**
$CH_3CO_2CH_2CH_3$ **Y**	$CH_3CH_2CO_2CH_3$ **Z**

give one mark for each correct answer (4 × 1) [4]

(c) (i) —CHO **or** aldehyde absent (1)
(ii) >CO **or** carbonyl absent (1)
(iii) —CO_2H **or** carboxylic acid present (1) [3]

(d) (i) CH_3CO_2H **or** ethanoic acid (1)
(ii) **Y** above (1) [2]

(e) none – no chiral carbon atoms present (1) [1]

Important values, constants and standards

molar gas constant	$R = 8.31\,J\,K^{-1}\,mol^{-1}$
Faraday constant	$F = 9.65 \times 10^{4}\,C\,mol^{-1}$
Avogadro constant	$L = 6.022 \times 10^{23}\,mol^{-1}$
electronic charge	$e = -1.60 \times 10^{-19}\,C$
molar volume of gas	$V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

The Periodic Table of Elements

Group 1	2											13	14	15	16	17	18
							1 H hydrogen 1.0										2 He helium 4.0
3 Li lithium 6.9	4 Be beryllium 9.0											5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0	10 Ne neon 20.2
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4	5	6	7	8	9	10	11	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5	18 Ar argon 39.9
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9	23 V vanadium 50.9	24 Cr chromium 52.0	25 Mn manganese 54.9	26 Fe iron 55.8	27 Co cobalt 58.9	28 Ni nickel 58.7	29 Cu copper 63.5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9	36 Kr krypton 83.8
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2	41 Nb niobium 92.9	42 Mo molybdenum 95.9	43 Tc technetium –	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re rhenium 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au gold 197.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium –	111 Rg roentgenium –	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

Key

atomic number
atomic symbol
name
relative atomic mass

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1	59 Pr praseodymium 140.9	60 Nd neodymium 144.4	61 Pm promethium –	62 Sm samarium 150.4	63 Eu europium 152.0	64 Gd gadolinium 157.3	65 Tb terbium 158.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
actinoids	89 Ac actinium –	90 Th thorium 232.0	91 Pa protactinium 231.0	92 U uranium 238.0	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –