



CHEMISTRY

9791/02

Paper 2 Part A Written

May/June 2018

MARK SCHEME

Maximum Mark: 100

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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This document consists of **9** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

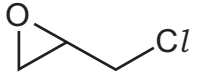
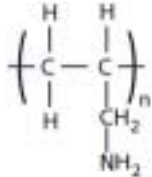
GENERIC MARKING PRINCIPLE 6:

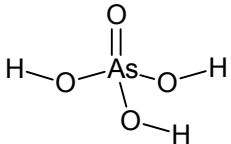
Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Question	Answer	Marks
1(a)(i)	No. subshells in a shell = n	1
1(a)(ii)	The 2p subshell is shielded (by 2s) or is more shielded (than 2s)	1
1(a)(iii)	Circle drawn for s orbital (1) and dumbbell drawn for p orbital (1)	2
1(a)(iv)	(4)s, (4)p, (4)d, (4)f	1
1(b)(i)	They have different / opposite / antiparallel spins	1
1(b)(ii)	1 pair of spin-antiparallel electrons in any one box and 2 spin-parallel electrons in the remaining two boxes	1
1(c)	$(\text{Cu}^{2+} 1s^2) 2s^2 2p^6 3s^2 3p^6 3d^9$	1
1(d)(i)	from 3p to 3s	1
1(d)(ii)	M1 $f = (3.00 \times 10^8 / 589 \times 10^{-9} =) 5.09 \times 10^{14}$ (5.0933786) (1) M2 $E = (6.63 \times 10^{-34} \times 5.09 \times 10^{14} =) 3.38 \times 10^{-19}$ OR $= 3.38 \times 10^{-22}$ (1) M3 Molar energy = $3.38 \times 10^{-22} \text{ kJ} \times 6.02 \times 10^{23} \text{ mol}^{-1} = 203 \text{ kJ mol}^{-1}$ (1)	3
1(e)(i)	The subshells (within a shell) all have the same energy in hydrogen	1
1(e)(ii)	The hydrogen spectrum is simpler / has fewer lines than those of other atoms NB Answer is contradicted by saying spectrum has only one line	1
2(a)(i)	$\frac{1}{4} \text{S}_8(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{S}_2\text{Cl}_2(\text{l})$ Correct species and balancing (1) Correct state symbols (1)	2
2(a)(ii)	Mass of $\text{S}_2\text{Cl}_2 = (1.69 \text{ g cm}^{-3} \times 10.0 \text{ cm}^3 =) 16.9 \text{ g}$ (1) Amount of $\text{S}_2\text{Cl}_2 = (16.9 \text{ g} / 135.2 \text{ g mol}^{-1} =) 0.125 \text{ mol}$ (1) Mass of sulfur = $(\frac{1}{4} \times 0.125 \text{ mol} \times 256.8 \text{ g mol}^{-1} = 8.025 \text{ g} =) 8.03$ (1)	3
2(a)(iii)	(Fractional) distillation	1

Question	Answer	Marks
2(b)	$\Delta_r H^\ominus(298 \text{ K}) = \{-59.4 - (2 \times (-49.8))\} \text{ kJ mol}^{-1} = (+)40.2 \text{ kJ mol}^{-1}$ $2 \times (-)49.8 \text{ OR } (-)99.6 \quad (1)$ Correct cycle (1)	2
2(c)(i)	Disproportionation (1) Oxidation number of sulfur increases and decreases (1)	2
2(c)(ii)	$\text{SO}_2 + 2\text{H}_2\text{S} \rightarrow 3/8\text{S}_8 + 2\text{H}_2\text{O}$ Correct species (allow S for S_8) (1) Correct balancing for correct equation (allow S for S_8) (1)	2
2(d)	$104^\circ - 105^\circ \quad (1)$ 2 bonding pairs (or 2 bonds) and 2 lone pairs (1) Repulsion between the bonding pairs is weaker than repulsions involving the lone pairs (1)	3
2(e)(i)	3:1 for M:M+2	1
2(e)(ii)	136: $\text{S}_2^{35}\text{Cl}^{37}\text{Cl}^+$ or $\text{S}_2^{37}\text{Cl}^{35}\text{Cl}^+$ (1) 138: $\text{S}_2^{37}\text{Cl}_2^+$ (1)	2
2(e)(iii)	$\text{S}_4\text{Cl}_2 \quad (1)$ $\text{Cl}-\text{S}-\text{S}-\text{S}-\text{S}-\text{Cl} \quad (1)$	2
3(a)(i)	Carboxylic acid (level).	1
3(a)(ii)	Methanoic acid or HCOOH or HCO_2H or CH_2O_2	1
3(a)(iii)	$\text{CHCl}_3 + 4\text{NaOH} \rightarrow \text{HCOONa} + 3\text{NaCl} + 2\text{H}_2\text{O}$ Species (1) Balancing (1)	2
3(b)(i)	Hashed and wedged bonds to show the 3D structure of $\text{NH}_3 \quad (1)$ (Trigonal) pyramid(al) (1)	2

Question	Answer	Marks
3(b)(ii)	<p>$\text{NH}_3(\text{aq})$ is pH 9–12 (1)</p> <p>$\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{NH}_4^+ + \text{OH}^-$ Correct products (1)</p> <p>$\text{Cl}_2 + \text{H}_2\text{O} \rightleftharpoons \text{HCl} + \text{HOCl}$ Correct products (1)</p> <p>Reversible reaction arrows for both reactions (1)</p>	4
3(b)(iii)	<p>The ammonia is neutralised / protonated / reacts with the acid OR</p> <p>The ammonia has lost its lone pair</p>	1
3(c)(i)	<p>H_2O Hydrogen bonding (1)</p> <p>CCl_4 Dispersion / London / instantaneous-dipole-induced-dipole / IDID / van der Waals forces between tetrachloromethane molecules (1)</p>	2
3(c)(ii)	Chloramine forms H-bonds with water molecules OR cannot form H-bonds with CCl_4 (1)	1
3(d)(i)	$2\text{Cl}_2 + \text{NH}_2\text{Cl} \rightarrow \text{NCl}_3 + 2\text{HCl}$	1
3(d)(ii)	<p>M1 Molar mass of $\text{NCl}_3 = \{14.0 + (3 \times 35.5)\} = 120.5 \text{ (g mol}^{-1}\text{)}$ AND Mol of $\text{NCl}_3 = (1.00 \text{ g} / 120.5) = 8.30 \times 10^{-3} \text{ (mol) (8.298755)}$ (1)</p> <p>M2 Mol of gas = $(2 \times 8.30 \times 10^{-3}) = 16.6 \times 10^{-3} \text{ (mol) (16.59751)}$ (1) Volume of gas = $(24000 \times 0.0166) = 398 \text{ cm}^3$ (1)</p>	3
3(e)	<p>Empirical formula of A = NH_2 (1)</p> <p>Formula of B = HCl or NH_4Cl (1)</p> <p>Structure of A = $\text{H}_2\text{N}-\text{NH}_2$ (1)</p>	3
4(a)(i)	$\text{C}_3\text{H}_8\text{O}_3$	1

Question	Answer	Marks
4(a)(ii)	Structure shows C=C double bond (1) Structure shows aldehyde group (1) H ₂ C=CHCHO, and propenal or prop-2-enal (1)	3
4(a)(iii)	2,3-dichloropropan-1-ol and 1,3-dichloropropan-2-ol 1 mark for each correct unambiguous skeletal, structural or fully displayed formula or a hybrid of these 1 mark for naming both correctly	3
4(a)(iv)	 Any correct unambiguous structure with the ring drawn (1)	1
4(a)(v)	Addition	1
4(b)	3C ₃ H ₆ O + PCl ₃ → 3C ₃ H ₅ Cl + H ₃ PO ₃ Correct formulae (1) Balancing of correct equation (1)	2
4(c)(i)	Both ammonia and 3-chloropropene dissolve in ethanol (1) Only ammonia is soluble in water / 3-chloropropene is insoluble in water (1)	2
4(c)(ii)	Any unambiguous form of (H ₂ C=CHCH ₂) ₂ NH	1
4(c)(iii)	Use an excess of (ethanolic) ammonia OR add 3-chloropropene dropwise (to ethanolic ammonia) (1) To minimise the chance of the amine produced reacting with chloropropene (1)	2
4(d)	 Use of correct carbon 'backbone', use of brackets bisecting bonds and (subscript) n (1) Correct repeat unit (1)	2

Question	Answer	Marks
5(a)(i)	6 protons, 7 neutrons, 5 electrons	1
5(a)(ii)	(weighted) average mass (1) masses are compared to 1 / 12 of (mass of neutral atom of) carbon-12 (1)	2
5(a)(iii)	RAM = $(12 \times 98.88877) + (13.003355 \times 1.11123) / 100$ (1) 12.01115 (1)	2
5(b)(i)	8	1
5(b)(ii)	Time = $3.5 \mu\text{s} / \sqrt{2} = 2.47 \times 10^{-6} \text{ s}$	1
5(c)(i)	^{13}C is present as a larger proportion in PDB AND Big fraction must be <1 OR $^{13}\text{C} / ^{12}\text{C}$ for the sample is smaller than for PDB	1
5(c)(ii)	$^{13}\text{C} / ^{12}\text{C} = (1.1 / 98.9) = 0.0111223458$ (1) $\delta = 1000 \times \{(0.0111223458 / 0.011237) - 1\} = -10(.2)$ AND Athlete did not use synthetic testosterone (1)	2
6(a)	Oxidation number = +5 (1) Structure (1) 	2
6(b)(i)	Mass of hydrated sodium thiosulfate $= (0.5 \text{ dm}^3 \times 1.00 \times 10^{-3} \times 248(.2)) = 0.124 \text{ g}$	1
6(b)(ii)	Dissolve in (deionised / distilled) water (in a suitable container) (1) Transfer to (500 cm ³ volumetric) flask with washings (1) Make up to the mark (with deionised / distilled water) (1) Invert / shake (1)	4

Question	Answer	Marks
6(c)	$11.65 \times V / (100 + V) = 4.0 \therefore 7.65V = 400 \therefore V = 52(.3) \text{ cm}^3$	1
6(d)(i)	To shift the position of the equilibrium (to right hand side) OR promote the forward reaction OR speed up the forward reaction OR to produce the I ₂	1
6(d)(ii)	Air would promote the oxidation of the arsenous acid / H ₃ AsO ₃	1
6(d)(iii)	The reaction (between iodide and arsenic acid) is slow	1
6(e)(i)	$\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \rightarrow 2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6$ OR	1
6(e)(ii)	Starch (1) Colour change from blue-black to colourless (1)	2
6(e)(iii)	Mol of arsenic = $(0.1 \times 6.65 \times 10^{-5}) = 6.65 \times 10^{-6} \text{ mol}$ (1) Mol of S ₂ O ₃ ²⁻ = $(2 \times 6.65 \times 10^{-6}) = 1.33 \times 10^{-5} \text{ mol}$ (1) Volume of S ₂ O ₃ ²⁻ = $(1.33 \times 10^{-5} / 1.00 \times 10^{-3}) \times 1000 \text{ cm}^3 = 13.3(0) \text{ cm}^3$ (1)	3