Cambridge Assessment International Education
Cambridge Pre-U Certificate

CHEMISTRY **9791/03**

Paper 3 Written **May/June 2019**

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.

Cambridge International will not enter into discussions about these mark schemes.

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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:

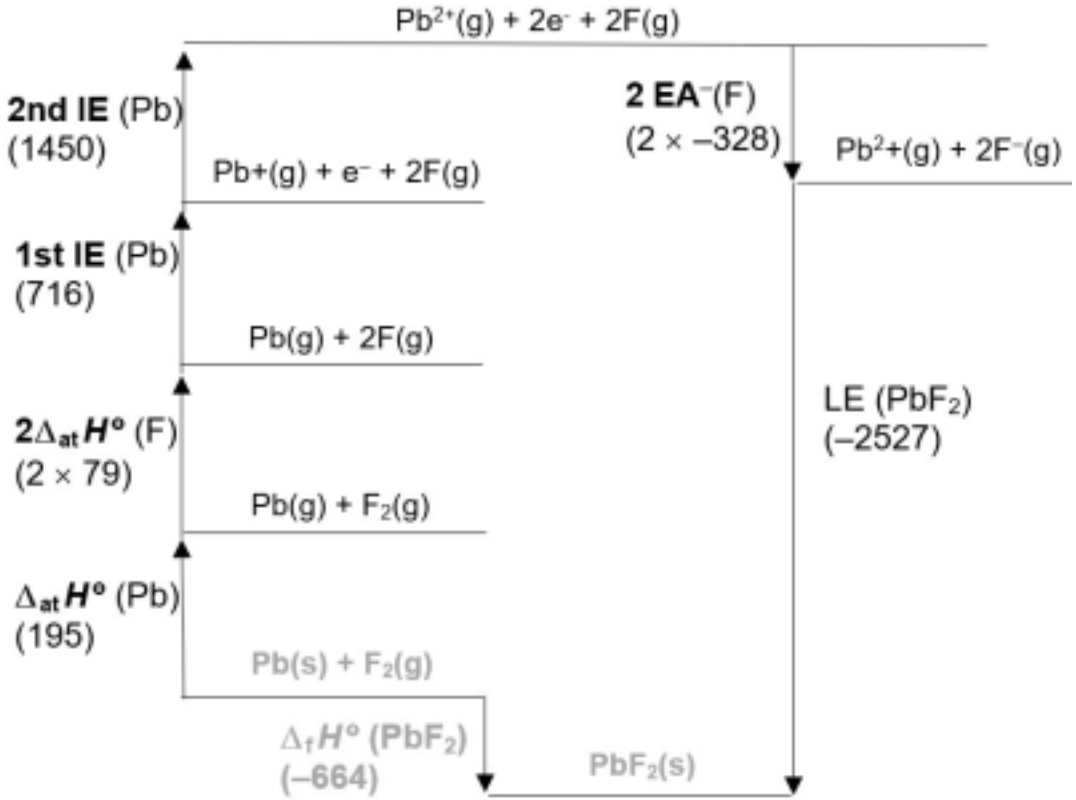
Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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)	Two drawn tangents at t=0 and t=20 (1) use at least 20 s width on the horizontal axis (1) both gradients correctly calculated (2)	**4**
1(a)(ii)	correctly read $[I^-]$ at t=0 and t=20 (1) calculates ratio of rates and ratio of concentrations **OR** Evidence of no constant half-life so not 1st order **and** not straight, so not 0 (1) rate is second order (1)	**3**
1(a)(iii)	so $[Fe^{3+}]$ is approximately constant (so the rate is only changed by $[I^-]$) (1)	**1**
1(b)	1st order (1) Expt 1 $\rightarrow$ Expt 2 rate doubles **AND** $[I^-]$ doubles so rate would increase $\times$ 4 and $[Fe^{3+}]$ halves (1)	**2**
1(c)	rate = $k[Fe^{3+}][I^-]^2$ (1)	**1**
1(d)(i)	initial rate = $k(0.150)(0.012)^2$ (1) $k = \frac{\text{initial rate}}{(0.150)(0.012)^2}$ = ……. (1) rearrangement and calculation (13.889) min 2 s.f. units : $dm^6\ mol^{-2}\ s^{-1}$ (1)	**3**
1(d)(ii)	Calculate *k* for either reaction in **(b)** and compares value to *k* from **(d)(i)** **OR** Calculates rate of an experiment in **(b)** using *k* from **(d)** (1) correct linked statement about temperature (1)	**2**

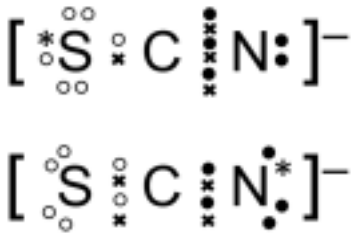
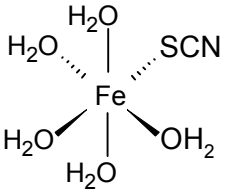
Question	Answer	Marks
1(e)(i)	$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow 2I^- (aq) + S_4O_6^{2-}(aq)$ 1 mark for correct species (1) 1 mark for rest correct (1)	**2**
1(e)(ii)	$I_2(0)$ to $I^-(-1)$ (1) $S_2O_3^{2-}$: S (+2) **AND** $S_4O_6^{2-}$: S (+2.5) (1)	**2**
1(f)(i)	The rate measured is the average rate so less than the initial rate / the concentration of the reagents decreases so rate gets slower (1)	**1**
1(f)(ii)	(Reaction of I_2 with $S_2O_3^{2-}$ regenerates I^-) I^- remains at the initial concentration (1)	**1**

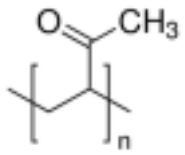
Question	Answer	Marks
2(a)	hexagonal (close packed) **AND** cubic (close packed) (1) hcp = ABAB arrangement (1) ccp = ABCABC arrangement (1)	**3**
2(b)(i)	simplest (1) repeating unit (1)	**2**
2(b)(ii)	ccp correctly mentioned in either (1) (In NaCl) Na^+ occupy all octahedral holes (in an array of halide ions) (1) (In CaF_2) F^- occupy all tetrahedral holes (in an array of Ca^{2+} ions) (1)	**3**

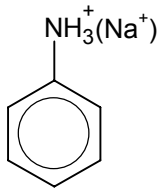
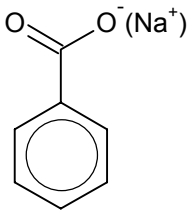
Question	Answer	Marks
2(c)(i)	 Atomisation of Pb and F (1) 1st and 2nd ionisation of Pb, both arrows going up (1) Total charge of every level is zero (1) EA of F with correct direction (1) LE with correct direction (1) state symbols (1)	**6**
2(c)(ii)	Correct expression (1) LE = –2527 (kJ mol^{-1}) (1)	**2**

Question	Answer	Marks
2(c)(iii)	ionic radius of I^- is greater than that of F^- **OR** I^- ion is more polarisable / distorted (1) PbI_2 has greater contribution from covalent bonding / is more covalent (1)	**2**
2(d)(i)	tetrahedral (1) 109.5° (1)	**2**
2(d)(ii)	$PbCl_4 \rightarrow PbCl_2 + Cl_2$ (1)	**1**
2(d)(iii)	PbF_4 is an ionic solid / (the bonding) is ionic / F^- has ionic attractions (1) $PbCl_4$ is molecular (1) Ionic bonds are stronger than intermolecular forces (1)	**3**

Question	Answer	Marks
3(a)	ferritin stores iron and releases it in a way that controls the overall level (1) myoglobin binds oxygen (using a haem group) (1)	**2**
3(b)(i)	6 (1)	**1**
3(b)(ii)	RFM = 482.0 (1) moles = $\frac{14.46}{481.8}$ = 0.0300 **AND** conc = $\frac{0.0300}{0.400}$ = 0.0750 (mol dm^{-3}) (1) $K_a = [H^+]^2 / [Fe^{3+}(aq)]$; $6.0 \times 10^{-3} = [H^+]^2 / 0.0750$ (1) $[H^+] = \sqrt{(6.0 \times 10^{-3})} \times (0.0750) = 0.0212$ (1) $pH = -\log_{10} [H^+] = -\log_{10} (0.0212) = 1.67$ (1) 2 d.p.	**5**
3(b)(iii)	Colour dominated by $[Fe(OH)(H_2O)_5]^{2+}$ (1)	**1**
3(b)(iv)	(less acidic) as O-H bond less easy to break / less weakened / water less polarised	**1**
3(c)(i)	$Fe^{2+} \rightarrow Fe^{3+} + e^-$ **AND** $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ (1) $5Fe^{2+} + 8H^+ + MnO_4^- \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$ (1)	**2**
3(c)(ii)	mention of ppt of iron (II or III) hydroxide or MnO_2 (1)	**1**

Question	Answer	Marks
3(d)(i)	 (1+1)	**2**
3(d)(ii)	Both S and N have lone pairs of electrons (1) Dative / coordinate covalent bonds formed (with the metal) (1)	**2**
3(d)(iii)	$[Fe(H_2O)_5(SCN)]^{2+}$ (1)  (1)	**2**

Question	Answer	Marks
4(a)(i)	nucleophilic addition (1)	**1**
4(a)(ii)	Correct dipoles on CO (1) Arrow from lone pair of CN^- to C of C=O **AND** Arrow from C=O bond to O (1) Intermediate shown with negative charge (1) Arrow from O^- to H+ or H of H_2O (1)	**4**
4(a)(iii)	planar around C of C=O (1) attack equally likely on either side (1)	**2**
4(a)(iv)	FGL: CN = 3 **AND** COOH = 3 (1) type of reaction: hydrolysis (1) reagent: H^+ / dilute acid (1)	**3**
4(b)(i)	Sideways overlap of / perpendicular **p orbitals** (of C) (1)	**1**
4(b)(ii)	No, (as Markovnikov would predict) a 2° carbocation is more stable and this is formed from a 1° carbocation **OR** Yes as the 2° carbocation is destabalised by e^- withdrawing C=O (1)	**1**
4(c)	Product from **(b)(ii)**. The butenone in **(b)** will react with the HCN moving the position of the equilibrium in **(c)** to the left until all the butenone has undergone reaction **(b)**. (1)	**1**
4(d)	 (2) correct side chain (1) rest of structure (1)	**2**
4(e)	$\ln K = 282 / (8.314)(298) = 0.114$ (1) $K = 1.12$ (1)	**2**

Question	Answer	Marks
5(a)(i)	CH_3Cl / $AlCl_3$ to generate CH_3^+ (1) Arrow from benzene bond to CH_3^+ (1) Structure of the methylbenzenium ion (1) Loss of H^+ to form HCl and arrow from C-H to ring (1)	**4**
5(b)(i)	2, 6 position has twice the probability of 4 position (1)	**1**
5(b)(ii)	steric hindrance less for position 4 so 2, 6 positions slightly less likely (1)	**1**
5(c)(i)	C_6H_5MgBr (1)	**1**
5(c)(ii)	CO_2 (1)	**1**
5(d)	COOH group directs 3, 5 (1) whereas CH_3 directs 2, 4 (1)	**2**
5(e)	**X** = aniline / phenylamine / benzenamine **Y** = benzoic acid / benzenecarboxylic acid **Z** = phenol All three correct = 2 marks; One correct = 1 mark **T** = hydrochloric acid (1) **C**  **D**  (1+1)	**5**

Question	Answer	Marks
5(f)(i)	Phenol is more acidic (1) $C_6H_5O^-$ has (–)ve charge / lone pair delocalised into π system / ring **OR** C_6H_5 –I effect weakens O-H bond (1)	**2**
5(f)(ii)	$C_2H_5O^-$ has electron donating **R** group which reduces the stability of the anion C_2H_5 has +I strengthens O-H bond (1)	**1**