Mark Scheme (Results)

October 2017

Pearson Edexcel International Advanced Level In Chemistry (WCH05) Paper 01 Transition Metals and Organic Nitrogen Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	**1. The only correct answer is C** ***A*** *is not correct because K, C and N are not +6* ***B*** *is not correct because N, H, V and O are not +6* ***D*** *is not correct because Co and Cl are not +6*	**(1)**

Question Number	Correct Answer	Mark
2	**2. The only correct answer is A** ***B*** *is not correct because complex is linear* ***C*** *is not correct because complex is tetrahedral* ***D*** *is not correct because molecule is tetrahedral*	**(1)**

Question Number	Correct Answer	Mark
3	**3. The only correct answer is D** ***A*** *is not correct because amphoteric behaviour* ***B*** *is not correct because acid/base reaction* ***C*** *is not correct because acid/base reaction*	**(1)**

Question Number	Correct Answer	Mark
4	**4. The only correct answer is B** ***A*** *is not correct because* Ag^+ *does not disproportionate* ***C*** *is not correct because* Ag^+ *does not disproportionate* ***D*** *is not correct because* Cu^+ *can disproportionate*	**(1)**

Question Number	Correct Answer	Mark
5	**5. The only correct answer is C** ***A*** *is not correct because oxidation number does not increase by 2* ***B*** *is not correct because oxidation number does not increase by 2* ***D*** *is not correct because oxidation number does not increase by 2*	**(1)**

Question Number	Correct Answer	Mark
6	**6. The only correct answer is D** ***A*** *is not correct because solubility does not affect the equilibrium position* ***B*** *is not correct because solubility does not affect the equilibrium position* ***C*** *because the enthalpy change does not affect the equilibrium position*	**(1)**

Question Number	Correct Answer	Mark
7(a)	**7(a). The only correct answer is A** ***B*** *is not correct because monomer is not CH2=CH(CONH2)* ***C*** *is not correct because monomer is not CH2=CH(CONH2)* ***D*** *is not correct because monomer is not CH2=CH(CONH2)*	**(1)**

Question Number	Correct Answer	Mark
7(b)	**7(b). The only correct answer is B** ***A*** *is not correct because repeat unit does not contain a CONH link* ***C*** *is not correct because repeat unit is made from an amine and an acid, not a diamine and dioic acid* ***D*** *is not correct because repeat unit does not contain a CONH link*	**(1)**

Question Number	Correct Answer	Mark
8	**The only correct answer is C** ***A*** *is not correct because answer is not -208 -(3x-120)* ***B*** *is not correct because answer is not 208 + 120* ***D*** *is not correct because answer is not 208 -120*	**(1)**

Question Number	Correct Answer	Mark
9	**The only correct answer is D** ***A*** *is not correct because COOH is not dissociated* ***B*** *is not correct because NH2 is not protonated* ***C*** *is not correct because CH2OH is dissociated*	**(1)**

Question Number	Correct Answer	Mark
10	**10. The only correct answer is C** ***A*** *is not correct because alanine can react with either* NH_2 *or* $COOH$ *in glycine and each dipeptide has enantiomers* ***B*** *is not correct because alanine can react with either* NH_2 *or* $COOH$ *in glycine and each dipeptide has enantiomers* ***D*** *is not correct because alanine can react with either* NH_2 *or* $COOH$ *in glycine and each dipeptide has enantiomers*	**(1)**

Question Number	Correct Answer	Mark
11(a)	**11(a). The only correct answer is B** ***A*** *is not correct because primary alcohol present on left of benzene ring* ***C*** *is not correct because secondary amine present* ***D*** *is not correct because benzene ring with* OH *group present*	**(1)**

Question Number	Correct Answer	Mark
11(b)	**11(b). The only correct answer is B** **A** *is not correct because number of* H *is incorrect* **C** *is not correct because number of* H *is incorrect* **D** *is not correct because* number *of* H *is incorrect*	**(1)**

Question Number	Correct Answer	Mark
12(a)	**12(a). The only correct answer is B** ***A*** *is not correct because there are 5 peaks:* CH_3 *on left,* CH_2 *next to O, next* CH_2*, H next to 2 methyl, pair of methyl* ***C*** *is not correct because there are 5 peaks:* CH_3 *on left,* CH_2 *next to O, next* CH_2*, H next to 2 methyl, pair of methyl* ***D*** *is not correct because there are 5 peaks:* CH_3 *on left,* CH_2 *next to O, next* CH_2*, H next to 2 methyl, pair of methyl*	**(1)**

Question Number	Correct Answer	Mark
12(b)	**12(b). The only correct answer is A** ***B*** *is not correct because only singlet is for left hand methyl hydrogens* ***C*** *is not correct because only singlet is for left hand methyl hydrogens* ***D*** *is not correct because only singlet is for left hand methyl hydrogens*	**(1)**

Question Number	Correct Answer	Mark
12(c)	**12(c). The only correct answer is B** ***A*** *because alkane C-H present in X and hydrolysis products* ***C*** *because acid C=O is in one hydrolysis product but not in X* ***D*** *because alkane C-H present in X and hydrolysis products*	**(1)**

Question Number	Correct Answer	Mark
12(d)	**12(d). The only correct answer is A** ***B*** *is not correct because 43 peak comes from CH_3CO* ***C*** *is not correct because 87 peak comes from molecule without CH_3CO fragment* ***D*** *is not correct because 129 peak comes from molecule without one H*	**(1)**

Question Number	Correct Answer	Mark
13	**13. The only correct answer is B** ***A*** *is not correct because 1 mol gives 6 CO_2 and 5H_2O so is C_6H_{10}* ***C*** *is not correct because 1 mol gives 6 CO_2 and 5H_2O so is C_6H_{10}* ***D*** *is not correct because 1 mol gives 6 CO_2 and 5H_2O so is C_6H_{10}*	**(1)**

Question Number	Correct Answer	Mark
14a	**14(a). The only correct answer is D** ***A*** *is not correct because wrong molar mass used* ***B*** *is not correct because answer is based on mass, not mol* ***C*** *is not correct because the yield expression is inverted*	**(1)**

Question Number	Correct Answer	Mark
14(b)	**14(b). The only correct answer is C** **A** *is not correct because not all aspirin would crystallise* **B** *is not correct because the temperature would be above the boiling point of water* **D** *is not correct because insoluble impurities can be removed*	**(1)**

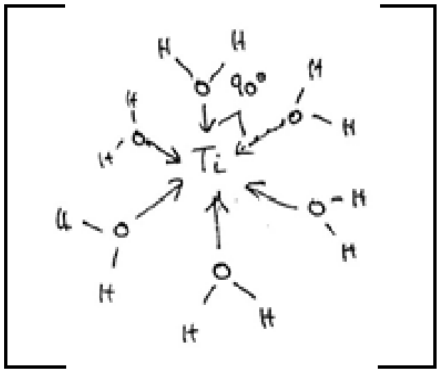
(Total for Section A = 20 marks)

Section B

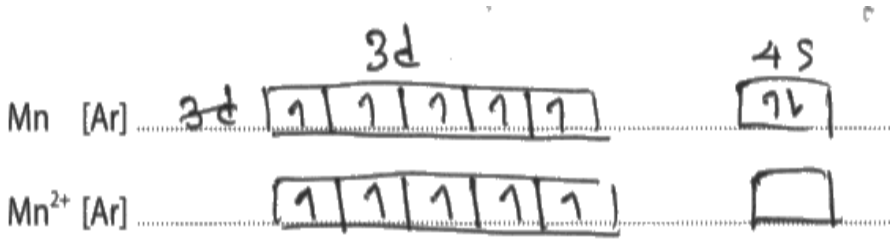
Question Number	Acceptable Answers	Reject	Mark
***15a**	**M1** The second member (of each pair) has one more proton/more protons/greater (effective) nuclear charge (so greater attraction of the electron to the nucleus) ALLOW greater atomic number **(1)** IGNORE more electrons charge increases **M2** Outer electrons in Ti are shielded/screened by (3)d (electrons) OR Outer electrons in Ca are not shielded/screened by (3)d **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***15b**	**M1** First two electrons removed from Ca, Sc and Ti are 4s/outermost sub-shell/ fourth shell **(1)** **M2** Second electron removed from K is from 3p/ inner (sub-)shell (which requires more energy) **(1)**		**(2)**

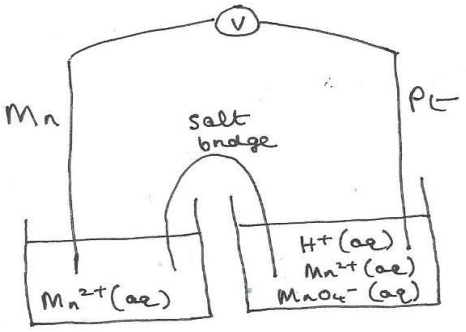
Question Number	Acceptable Answers	Reject	Mark
15c	**M1** In Sc and Ti the last/an/one electron is placed in/have an electron in the (3)d sub-shell/ d-orbital ALLOW Electronic configurations of Sc and Ti given showing $3d^1$ and $3d^2$ Both have one or two electrons in the d sub-shell **(1)** **M2** Sc does not form a (stable) ion with incomplete d orbital/ unpaired d electron in its ion/ does not have a partially filled d sub-shell (but Ti does). OR Sc does not have any d electrons in any of its ions **(1)**	Just both have electrons in d	**(2)**

Question Number	Acceptable Answers	Reject	Mark
15d	**M1**  Diagram **and** octahedral **and** angle of 90°(and 180°) IGNORE Missing square brackets, charge No need for clear O-Ti bonds for this mark **(1)** **M2** Dative covalent bonds OR all bonds clearly O of H_2O to Ti OR Coordinate bonds IGNORE δ charges on water unless incorrect **(1)**	Bonds drawn from hydrogen of water OR Full charges on H and O of water	**(2)**

(Total for Question 15 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
16a(i)	Mn [Ar] $4s^2\ 3d^5$ / $3d^5\ 4s^2$ **and** Mn^{2+} [Ar] $(4s^o)\ 3d^5$ OR $3d^5(4s^o)$ ALLOW Full configurations $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ for [Ar] OR  With half headed or full headed arrows		**(1)**

Question Number	Acceptable Answers	Reject	Mark
16a(ii)	The (3)d orbitals in Mn^{2+} are all half full OR (3)d orbitals are filled with unpaired electrons / electrons with the same spin OR (3)d orbitals have maximum number of unpaired electrons OR A half-filled (3)**d** (sub-)shell/set of (3)dorbitals (is very stable)	...orbital... Half-filled 3d orbital Partially filled 3d sub-shell	**(1)**

Question Number	Acceptable Answers	Reject	Mark
16b(i)	 IGNORE charges / names of electrodes **M1** Beaker with Mn electrode in $Mn^{2+}(aq)$ ALLOW soluble Mn(II) compounds **(1)** **M2** Beaker with Pt electrode in $Mn^{2+} + MnO_4^- + H^+$ (all aq) Allow names for ions and just 'acid' **(1)** If no solution levels shown at correct level only award one of M1 and M2 **M3** Salt bridge **and** voltmeter correctly connected OR Details of salt bridge – (Saturated) solution of potassium/sodium/ammonium nitrate on filter paper/in tube (containing agar gel) **(1)** **M4** All solutions 1 mol dm^{-3} **and** T = 298 K / 25^0C ALLOW $[H+] \geq 1$ **(1)** IGNORE references to pressure	Acid in Mn cell Reject incorrect salts	**(4)**

Question Number	Acceptable Answers	Reject	Mark
16b(ii)	(+) 2.7(0)(V) IGNORE Negative or lack of sign		**(1)**

Question Number	Acceptable Answers	Reject	Mark
16b(iii)	$5Mn + 2MnO_4^- + 16H^+ \rightarrow 7Mn^{2+} + 8H_2O$ Species including charges ALLOW $2Mn^{2+} + 5Mn^{2+}$ **(1)** Balancing dependent on correct species **(1)** ALLOW Total (1) for correct equation in reverse OR for one slip if a charge or letter 'n' omitted IGNORE State symbols even if incorrect		**(2)**

Question Number	Acceptable Answers	Reject	Mark
16(c)	**For correct entities** **M1** $E^{\ominus}$ for V^{3+} to V^{2+} = (-0.26 -(-1.19)) = (+) 0.93 (V) **(1)** **M2** $E^{\ominus}$ for V^{2+} to V = (-1.18 -(-1.19)) = (+) 0.01 (V) **(1)** **M3** Both reactions are feasible because $E^{\ominus}$ values are positive (forming Mn^{2+} and V) This is a **standalone** mark for feasibility of any one reaction with possible TE for negative $E^{\ominus}$ value **(1)** **M4** Mn^{2+} and (mainly) V^{2+} (and V) form because second reaction is close to zero so equilibrium occurs **(1)** **If MnO_4^- used** 1 max for M1 and M2, then M3 and M4 to 3max V^{3+} to VO^{2+} (+)1.17 (V) VO^{2+} to VO^{2+} (+)0.51 (V) V^{2+} to V^{3+} (+)1.77 (V) V to V^{2+} (+)2.69 (V) OR If only Vanadium electrode potentials used 1 max for M1 and M2, then M3 and M4 to 3max VO^{2+} to V^{2+} (+)0.60 (V) V^{3+} to V (+)0.92 (V) VO^{2+} to V (+)1.52 (V)		**(4)**

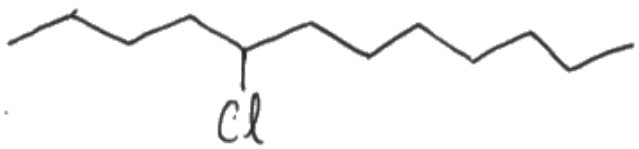
Question Number	Acceptable Answers	Reject	Mark
16d(i)	$Mn^{2+}(aq) + 2OH^-(aq) \rightarrow Mn(OH)_2(s)$ OR $[Mn(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Mn(OH)_2(s) + 6H_2O(l)$ OR $[Mn(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow [Mn(H_2O)_4(OH)_2](s) + 2H_2O(l)$ Notice state symbols are required.	Mg for Mn $MnOH_2$ NaOH	**(1)**

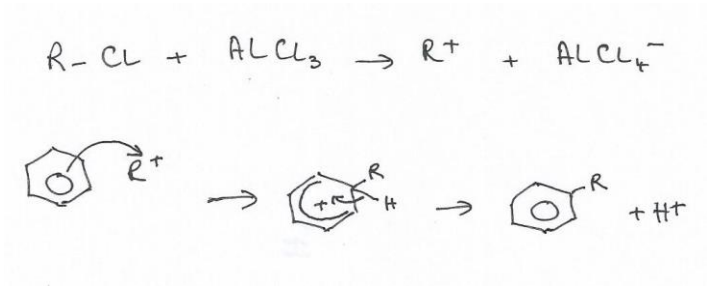
Question Number	Acceptable Answers	Reject	Mark
16d(ii)	(Very) pale brown/ buff/ off-white ALLOW Cream OR cream(y) brown OR cream(y) white OR beige IGNORE precipitate/gelatinous	White Yellow Orange Red/brown Brown Any other colour	**(1)**

Question Number	Acceptable Answers	Reject	Mark
16d(iii)	Manganese(IV) oxide/ manganese dioxide/ MnO_2 ALLOW Manganese(IV) hydroxide /$Mn(OH)_4$ OR MnO_2, manganese oxide	All other manganese oxides of hydroxides Manganese oxide alone	**(1)**

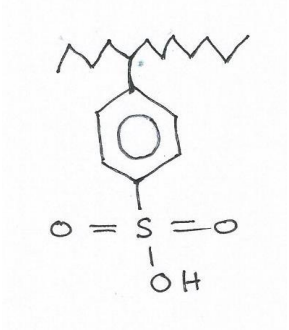
(Total for Question 16 = 16 marks)

Question Number	Acceptable Answers	Reject	Mark
17a(i)	C = 12 **and** H = 25 OR $C_{12}H_{25}$ / $H_{25}C_{12}$ OR Twelve carbons **and** twenty five hydrogens		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17a(ii)	**M1** Compound: $CH_3(CH_2)_3CHCl(CH_2)_6CH_3$ OR $CH_3(CH_2)_6CHCl(CH_2)_3CH_3$ OR $CH_3CH_2CH_2CH_2CHClCH_2CH_2CH_2CH_2CH_2CH_2CH_3$ ALLOW Displayed formula OR Skeletal formula  ALLOW other halogens **(1)** **M2** Catalyst: (anhydrous)$AlCl_3$ / aluminium chloride ALLOW $FeCl_3$ / iron(III) chloride OR Other halogens **(1)** Mark independently	$C_{12}H_{25}Cl$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17a(iii)	 **M1** Equation for formation of R^+ Accept R, $C_{12}H_{25}$ or any halogenalkane and any charge carrier on the left, or SO_3Na/H attached to ring AND $R^{\delta+}$… $AlCl_4^{\delta-}$ as product and elctrophile **(1)** **M2** Curly arrow from ring to R^+ **and** formation of intermediate with horseshoe in ring covering at least 3C **but** with **opening** facing correct C **and** charge within horseshoe **(1)** **M3** Curly arrow from C-H **bond** to inside of ring Ignore arrows from negative ions **and** final products **(1)**	Dotted lines for bonds unless part of 3D structure	**(3)**

Question Number	Acceptable Answers	Reject	Mark
17a(iv)	Fuming sulfuric acid OR sulfuric acid (saturated) with/and sulfur trioxide OR oleum/ $H_2S_2O_7$ ALLOW Sulfur trioxide OR fuming concentrated sulfuric acid IGNORE Formulae	Concentrated sulfuric acid alone SO_3H/sulfonic acid Sulfur dioxide	**(1)**

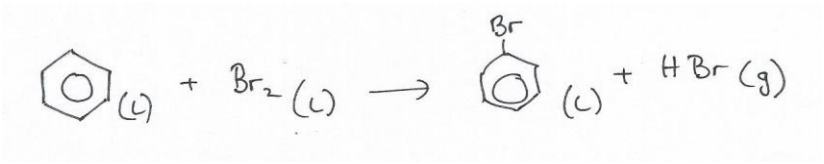
Question Number	Acceptable Answers	Reject	Mark
17a(v)	 IGNORE Lone pairs ALLOW O-H displayed or not displayed OR **Two** arrows form S to O / Dative covalent bonds for the double bonds		**(1)**

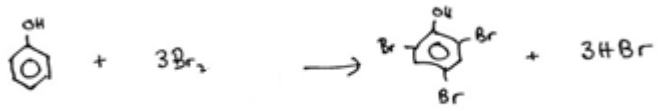
Question Number	Acceptable Answers	Reject	Mark
17a(vi)	Sodium hydroxide/ NaOH/ Sodium carbonate/ Na_2CO_3/ Sodium hydrogencarbonate/ $NaHCO_3$	Na	**(1)**

Question Number	Acceptable Answers	Reject	Mark
***17b(i)**	There are (strong) London forces between molecules of C_6H_5R **and** (strong) hydrogen bonds between water molecules **(1)** (Formation of) London forces between C_6H_5R and water… ….do not compensate for energy needed to break bonds OR ….too weak to break London forces/ hydrogen bonds OR Just London forces between C_6H_5R and water are too weak OR Hydrogen bonds cannot form between the two substances **(1)** IGNORE Hydrophobic/ hydrophilic comments	Dipole-dipole forces Hydrogen bonds in C_6H_5R	**(2)**

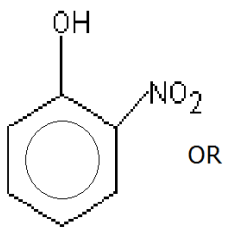
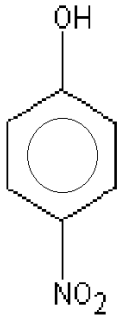
Question Number	Acceptable Answers	Reject	Mark
17b(ii)	**M1** The detergent contains an ionic group OR Detergent contains $-SO_3^-$ and Na^+ ions **(1)** **M2** Energy released when ions are hydrated compensates for energy needed to break (intermolecular) bonds in the components of the solution. ALLOW Strong ion-dipole forces (form) OR forces between $-SO_3^-$ and $H^{(\delta+)}$ in water OR oxygen of detergent forms hydrogen bonds with hydrogen of water **(1)**		**(2)**

(Total for Question 17= 13 marks)

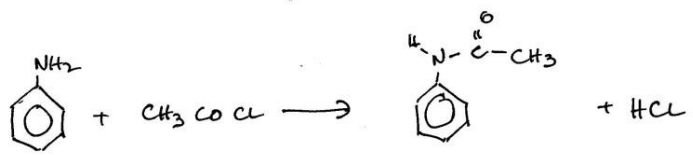
Question Number	Acceptable Answers	Reject	Mark
18a(i)	 ALLOW $C_6H_6(l) + Br_2(l) \rightarrow C_6H_5Br(l) + HBr(g)$ **M1** Equation **(1)** **M2** State symbols **(1)** IGNORE catalysts unless UV		**(2)**

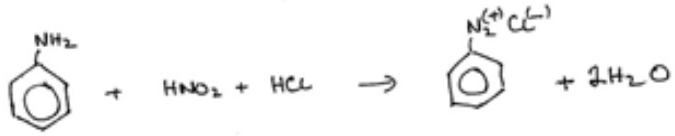
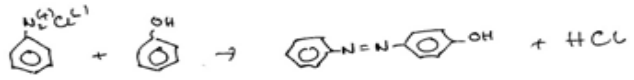
Question Number	Acceptable Answers	Reject	Mark
18a(ii)	 IGNORE State symbols even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
***18a(iii)**	**M1** Lone/non-bonding/electron pair on O atom/OH group of phenol **(1)** **M2** EITHER overlaps with pi system allow overlaps with any p orbital(s) of benzene OR increases electron density of ring (so increasing susceptibility to reaction with electrophiles) OR Donates / pushes electrons to the ring IGNORE increases charge density **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
18b(i)	**M1**  OR  2-nitrophenol 4-nitrophenol ALLOW Kekule structures 2,4-dinitrophenol or other substituted nitrophenols $C_6H_4(OH)(NO_2)$ etc **(1)** **M2** Mechanism: electrophilic substitution **(1)** Mark independently	Look out for NO_3 **SN1/2**	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18b(ii)	**Scroll down** **M1** $C_6H_5NH_3^+$ OR $C_6H_5NH_3^{(+)}$ $NO_3^{(-)}$ OR With benzene ring drawn out **(1)** **M2** Acid-base reaction/ neutralisation/ salt formation / protonation IGNORE acid-alkali **(1)** Mark independently	Nitration of ring	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18c			**(2)**
	Balanced equation **(1)** Displayed structure of product ALLOW Undisplayed methyl group/ NH group Kekule or delocalised ring **(1)**		

Question Number	Acceptable Answers	Reject	Mark
18d	**M1** First step:  OR $C_6H_5NH_2 + HNO_2 + HCl \rightarrow C_6H_5N_2^{(+)}Cl^{(-)} + 2H_2O$ ALLOW $HNO_2 + HCl$ above arrow OR $C_6H_5NH_2 + NaNO_2 + 2HCl \rightarrow C_6H_5N_2^{(+)}Cl^{(-)} + 2H_2O + NaCl$ OR Displayed OR Using H^+ /any strong acids eg $C_6H_5NH_2 + HNO_2 + H^+ \rightarrow C_6H_5N_2^+ + 2H_2O$ **(1)** **M2 Conditions** Temperature between 0^0C and 10^0C / below 10^0C **(1)** **M3** Second step:  $C_6H_5N_2^{(+)}Cl^{(-)} + C_6H_5OH \rightarrow C_6H_5N{=}NC_6H_4OH + HCl$ ALLOW $C_6H_5N_2^+ + C_6H_5OH \rightarrow C_6H_5N{=}NC_6H_4OH + H^+$ Substitution on any part of the benzene ring **(1)** NOTE Diazonium ion may be shown as $N{=}N^+$ or with triple bond in any of these steps and in dye can be N_2 IGNORE Position of plus sign Mark independently		**(3)**

(Total for Question 18= 14 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
***19a**	**M1** The energy difference between the two sets of (d-)orbitals is different in $Cr^{2+}(aq)$ and $Cr^{3+}(aq)$ OR (d) orbital energies are different OR Different charges alter (d) energy levels OR Different splitting of d) orbital**s**/energy levels **(1)** **M2** So the energy **absorbed** (in the transition) is different OR Frequency/wavelength **absorbed** is different **(1)**	…orbital… Energy emitted …emitted…	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19b(i)	**Method 1** The energy needed to remove six electrons/ the sum of the first to the sixth ionisation energies would be extremely high **(1)** The ionization energy is (much) greater than the lattice energy **(1)** **Method 2** A highly charged ion/6+ ion/ small positive ion… …is highly polarizing **(2)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19b(ii)	$2CrO_3 + H_2O \rightarrow Cr_2O_7^{2-} + 2H^+$ OR $2CrO_3 + H_2O \rightarrow H_2Cr_2O_7$ ALLOW $CrO_3 + H_2O \rightarrow CrO_4^{2-} + 2H^+$ OR $CrO_3 + H_2O \rightarrow H_2CrO_4$ IGNORE state symbols even if incorrect	Chromium hydroxides	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19b(iii)	$Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$ ALLOW Na or K ions for both dichromate and hydroxide Reversible arrows IGNORE state symbols even if incorrect	$Cr_2O_7^{2-} + OH^- \rightarrow 2CrO_4^{2-} + H^+$ OR $Cr_2O_7^{2-} + H_2O \rightarrow 2CrO_4^{2-} + H^+$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19c(i)	**M1** Chromium ions go from orange to green **(1)** **M2** Iron ions go from pale green to yellow/orange/red/brown **(1)** OR **M1** A product ion and a reactant ion similar colours **(1)** **M2** EITHER Cr(III) and Fe(II) are green OR Cr(VI) and Fe(III) are orange **(1)** ALLOW Any two colours correct with their ions 1 max		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19c(ii)	Heating under reflux OR reflux under heat ALLOW Refluxing / reflux IGNORE (simple) distillation OR fractional distillation IGNORE addition of other chemicals		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19c(iii)	Mol $Cr_2O_7^{2-}$ at start = ((100 x 0.0210)/1000) = 2.10 x 10^{-3} / 0.00210 IGNORE SF except 1 SF		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(iv)	**M1** Mol Fe^{2+} = ((25 x 0.015)/1000) =3.75 x 10^{-4} / 0.000375 **(1)** **M2** Mol $Cr_2O_7^{2-}$ = ((3.75 x 10^{-4})/6) =6.25 x 10^{-5} OR their mol Fe^{2+}/6 **(1)** **M3** Mol in 200cm^3 solution after reaction = ((6.25 x 10^{-5}) x 200/18.6) =6.72 x 10^{-4} / 0.000672 OR their mol in 200cm^3 solution may well be their mol x 8 **(1)** Mol used in reaction = ((2.1 x 10^{-3}) – (6.72 x 10^{-4}) =1.427957 x 10^{-3} / 0.00142797 OR their TE subtraction **(1)** TE on each step For example using 18.6 for volume in M1 (loses M1) gives 2.79 x 10^{-4} **M2** 4.65 x 10^{-5} **M3** 3.72 x 10^{-4} **M4** 1.73 x 10^{-3} IGNORE SF except 1 SF unless already penalised		**(4)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(v)	(1.4279 x 10^{-3} x 3/2) = 2.1419 x 10^{-3} (mol) / 0.0021419 TE on answer to (iv) x 1.5 IGNORE SF except 1 SF if not previously penalised TE from above gives 2.59(2) x 10^{-3}		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(vi)	Volume of ethanol in 1 cm^3 = $(2.14 \times 10^{-3} \times 58.3) = 0.1248748$ **(1)** TE on (v) x 58.3 % ABV = 12.5 **(1)** TE on their value providing less than 100% TE from above gives 15.1% IGNORE SF except 1 SF if not already penalised		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(d)	**M1** Circles around at least two of the four nitrogens and one oxygen **(1)** 3 mol as Cr can form a total of 6 bonds with two bonds per ligand ALLOW 3 mol as this give stable 5 /6 membered ring **(1)**		**(2)**

(Total for Question 19= 19 marks)