



Pearson

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 <i>A is not correct because K, C and N are not +6</i> <i>B is not correct because N, H, V and O are not +6</i> <i>D is not correct because Co and Cl are not +6</i> | (1) |

| Question Number | Correct Answer | Mark |
|-----------------|--|------------|
| 2 | 2. The only correct answer is A <i>B is not correct because complex is linear</i> <i>C is not correct because complex is tetrahedral</i> <i>D is not correct because molecule is tetrahedral</i> | (1) |

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

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

| Question Number | Correct Answer | Mark |
|-----------------|---|------------|
| 5 | 5. The only correct answer is C <i>A is not correct because oxidation number does not increase by 2</i> <i>B is not correct because oxidation number does not increase by 2</i> <i>D is not correct because oxidation number does not increase by 2</i> | (1) |

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

| Question Number | Correct Answer | Mark |
|-----------------|---|------------|
| 7(a) | 7(a). The only correct answer is A <i>B is not correct because monomer is not $\text{CH}_2=\text{CH}(\text{CONH}_2)$</i> <i>C is not correct because monomer is not $\text{CH}_2=\text{CH}(\text{CONH}_2)$</i> <i>D is not correct because monomer is not $\text{CH}_2=\text{CH}(\text{CONH}_2)$</i> | (1) |

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

| Question Number | Correct Answer | Mark |
|-----------------|---|------------|
| 8 | The only correct answer is C <i>A is not correct because answer is not $-208 -(3x-120)$</i> <i>B is not correct because answer is not $208 + 120$</i> <i>D is not correct because answer is not $208 -120$</i> | (1) |

| Question Number | Correct Answer | Mark |
|-----------------|--|------------|
| 9 | The only correct answer is D <i>A is not correct because COOH is not dissociated</i> <i>B is not correct because NH_2 is not protonated</i> <i>C is not correct because CH_2OH is dissociated</i> | (1) |

| Question Number | Correct Answer | Mark |
|-----------------|--|------------|
| 10 | <p>10. The only correct answer is C</p> <p><i>A is not correct because alanine can react with either NH₂ or COOH in glycine and each dipeptide has enantiomers</i></p> <p><i>B is not correct because alanine can react with either NH₂ or COOH in glycine and each dipeptide has enantiomers</i></p> <p><i>D is not correct because alanine can react with either NH₂ or COOH in glycine and each dipeptide has enantiomers</i></p> | (1) |

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

| Question Number | Correct Answer | Mark |
|-----------------|---|------------|
| 11(b) | <p>11(b). The only correct answer is B</p> <p><i>A is not correct because number of H is incorrect</i></p> <p><i>C is not correct because number of H is incorrect</i></p> <p><i>D is not correct because number of H is incorrect</i></p> | (1) |

| Question Number | Correct Answer | Mark |
|-----------------|---|------------|
| 12(a) | <p>12(a). The only correct answer is B</p> <p><i>A is not correct because there are 5 peaks: CH₃ on left, CH₂ next to O, next CH₂, H next to 2 methyl, pair of methyl</i></p> <p><i>C is not correct because there are 5 peaks: CH₃ on left, CH₂ next to O, next CH₂, H next to 2 methyl, pair of methyl</i></p> <p><i>D is not correct because there are 5 peaks: CH₃ on left, CH₂ next to O, next CH₂, H next to 2 methyl, pair of methyl</i></p> | (1) |

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

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

| Question Number | Correct Answer | Mark |
|-----------------|--|------------|
| 12(d) | 12(d). The only correct answer is A <i>B is not correct because 43 peak comes from CH₃CO</i> <i>C is not correct because 87 peak comes from molecule without CH₃CO fragment</i> <i>D is not correct because 129 peak comes from molecule without one H</i> | (1) |

| Question Number | Correct Answer | Mark |
|-----------------|---|------------|
| 13 | 13. The only correct answer is B <i>A is not correct because 1 mol gives 6 CO₂ and 5H₂O so is C₆H₁₀</i> <i>C is not correct because 1 mol gives 6 CO₂ and 5H₂O so is C₆H₁₀</i> <i>D is not correct because 1 mol gives 6 CO₂ and 5H₂O so is C₆H₁₀</i> | (1) |

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

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

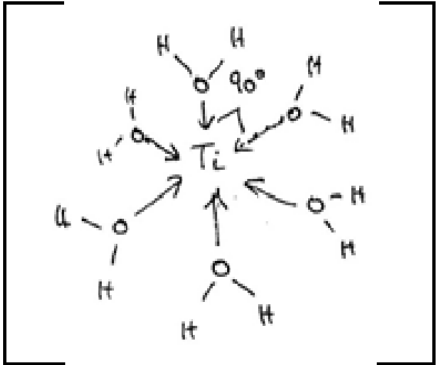
(Total for Section A = 20 marks)

Section B

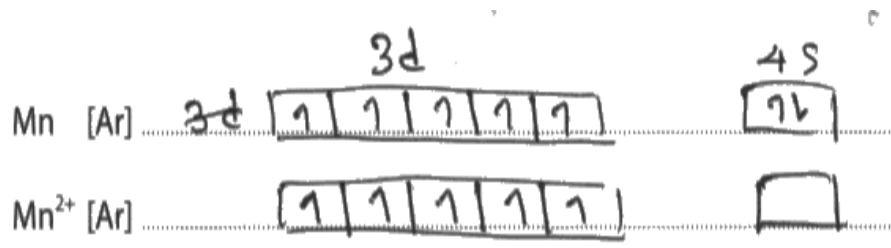
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| *15a | <p>M1</p> <p>The second member (of each pair) has one more proton/more protons/greater (effective) nuclear charge (so greater attraction of the electron to the nucleus)</p> <p>ALLOW greater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

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

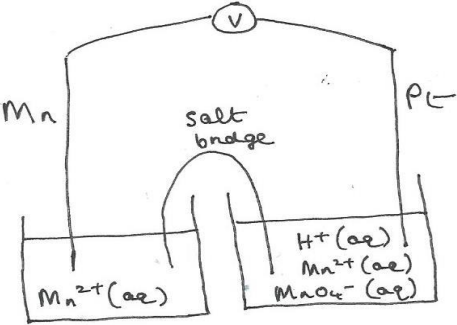
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--------------------------------------|------------|
| 15c | <p>M1</p> <p>In Sc and Ti the last/an/one electron is placed in/have an electron in the (3)d sub-shell/ d-orbital</p> <p>ALLOW</p> <p>Electronic configurations of Sc and Ti given showing 3d¹ and 3d²</p> <p>Both have one or two electrons in the d sub-shell (1)</p> <p>M2</p> <p>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).</p> <p>OR</p> <p>Sc does not have any d electrons in any of its ions (1)</p> | <p>Just both have electrons in d</p> | (2) |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|------------|
| 15d | <p>M1</p>  <p>Diagram and octahedral and angle of 90°(and 180°)</p> <p>IGNORE</p> <p>Missing square brackets, charge</p> <p>No need for clear O-Ti bonds for this mark (1)</p> <p>M2</p> <p>Dative covalent bonds</p> <p>OR</p> <p>all bonds clearly O of H₂O to Ti</p> <p>OR</p> <p>Coordinate bonds</p> <p>IGNORE</p> <p>δ charges on water unless incorrect (1)</p> | <p>Bonds drawn from hydrogen of water</p> <p>OR</p> <p>Full charges on H and O of water</p> | (2) |

(Total for Question 15 = 8 marks)

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 16a(i) | <p>Mn [Ar] $4s^2 3d^5$ / $3d^5 4s^2$</p> <p>and</p> <p>Mn^{2+} [Ar] $(4s^0) 3d^5$ OR $3d^5(4s^0)$</p> <p>ALLOW</p> <p>Full configurations $1s^2 2s^2 2p^6 3s^2 3p^6$ for [Ar]</p> <p>OR</p>  <p>Mn [Ar] $3d$ $\begin{array}{ c c c c c } \hline \uparrow & \uparrow & \uparrow & \uparrow & \uparrow \\ \hline \end{array}$ $\begin{array}{ c } \hline \uparrow\downarrow \\ \hline \end{array}$ $4s$</p> <p>Mn^{2+} [Ar] $\begin{array}{ c c c c c } \hline \uparrow & \uparrow & \uparrow & \uparrow & \uparrow \\ \hline \end{array}$ $\begin{array}{ c } \hline \\ \hline \end{array}$</p> <p>With half headed or full headed arrows</p> | | (1) |

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

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--|------------|
| 16b(i) |  <p>IGNORE charges / names of electrodes</p> <p>M1 Beaker with Mn electrode in $\text{Mn}^{2+}(\text{aq})$</p> <p>ALLOW soluble Mn(II) compounds (1)</p> <p>M2 Beaker with Pt electrode in $\text{Mn}^{2+} + \text{MnO}_4^- + \text{H}^+$ (all aq)</p> <p>Allow names for ions and just 'acid' (1)</p> <p>If no solution levels shown at correct level only award one of M1 and M2</p> <p>M3 Salt bridge and voltmeter correctly connected</p> <p>OR</p> <p>Details of salt bridge – (Saturated) solution of potassium/sodium/ammonium nitrate on filter paper/in tube (containing agar gel) (1)</p> <p>M4 All solutions 1 mol dm^{-3} and $T = 298 \text{ K} / 25^\circ\text{C}$</p> <p>ALLOW</p> <p>$[\text{H}^+] \geq 1$ (1)</p> <p>IGNORE references to pressure</p> | <p>Acid in Mn cell</p> <p>Reject incorrect salts</p> | (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) | $5\text{Mn} + 2\text{MnO}_4^- + 16\text{H}^+ \rightarrow 7\text{Mn}^{2+} + 8\text{H}_2\text{O}$ Species including charges ALLOW $2\text{Mn}^{2+} + 5\text{Mn}^{2+}$ (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) | <p>For correct entities</p> <p>M1 E^\ominus for V^{3+} to $V^{2+} = (-0.26 - (-1.19)) = (+) 0.93$ (V) (1)</p> <p>M2 E^\ominus for V^{2+} to V = $(-1.18 - (-1.19)) = (+) 0.01$ (V) (1)</p> <p>M3 Both reactions are feasible because E^\ominus values are positive (forming Mn^{2+} and V)</p> <p>This is a standalone mark for feasibility of any one reaction with possible TE for negative E^\ominus value (1)</p> <p>M4 Mn^{2+} and (mainly) V^{2+} (and V) form because second reaction is close to zero so equilibrium occurs (1)</p> <p>If MnO_4^- used</p> <p>1 max for M1 and M2, then M3 and M4 to 3max</p> <p>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)</p> <p>OR</p> <p>If only Vanadium electrode potentials used</p> <p>1 max for M1 and M2, then M3 and M4 to 3max</p> <p>VO^{2+} to V^{2+} (+)0.60 (V) V^{3+} to V (+)0.92 (V) VO^{2+} to V (+)1.52 (V)</p> | | (4) |

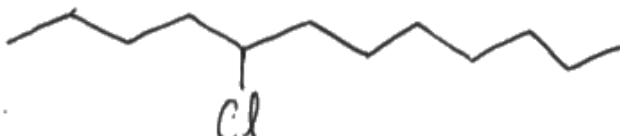
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|------------|
| 16d(i) | <p>$Mn^{2+}(aq) + 2OH^-(aq) \rightarrow Mn(OH)_2(s)$</p> <p>OR</p> <p>$[Mn(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Mn(OH)_2(s) + 6H_2O(l)$</p> <p>OR</p> <p>$[Mn(H_2O)_6]^{2+}(aq) + 2OH^-(aq)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

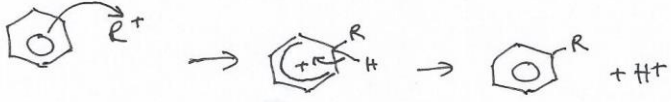
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|------------|
| 16d(ii) | (Very) pale brown/ buff/ off-white ALLOW Cream OR cream(y) brown OR cream(y) white OR beige IGNORE precipitate/gelatinous | White Yellow Orange Red/brown Brown Any other colour | (1) |

| 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) | <p>M1 Compound:</p> <p>CH₃ (CH₂)₃CHCl (CH₂)₆CH₃</p> <p>OR</p> <p>CH₃ (CH₂)₆CHCl (CH₂)₃CH₃</p> <p>OR</p> <p>CH₃CH₂CH₂CH₂CHClCH₂CH₂CH₂CH₂CH₂CH₂CH₃</p> <p>ALLOW</p> <p>Displayed formula</p> <p>OR Skeletal formula</p>  <p>ALLOW other halogens (1)</p> <p>M2 Catalyst: (anhydrous)AlCl₃ / aluminium chloride</p> <p>ALLOW</p> <p>FeCl₃ / iron(III) chloride</p> <p>OR</p> <p>Other halogens (1)</p> <p>Mark independently</p> | C ₁₂ H ₂₅ Cl | (2) |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|------------|
| 17a(iii) | <p style="text-align: center;"> $R-Cl + AlCl_3 \rightarrow R^+ + AlCl_4^-$  </p> <p>M1 Equation for formation of R⁺</p> <p>Accept R, C₁₂H₂₅ or any halogenalkane and any charge carrier on the left, or SO₃Na/H attached to ring</p> <p>AND</p> <p>R^{δ+}... AlCl₄^{δ-} as product and electrophile (1)</p> <p>M2 Curly arrow from ring to R⁺</p> <p>and</p> <p>formation of intermediate with horseshoe in ring covering at least 3C but with opening facing correct C</p> <p>and charge within horseshoe (1)</p> <p>M3 Curly arrow from C-H bond to inside of ring</p> <p>Ignore arrows from negative ions</p> <p>and final products (1)</p> | <p>Dotted lines for bonds unless part of 3D structure</p> | (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 ₃ H/sulfonic acid Sulfur dioxide | (1) |

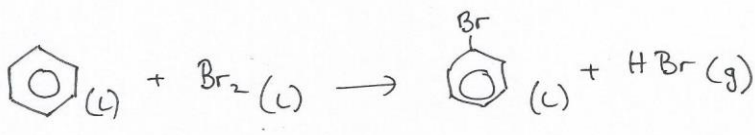
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 17a(v) | <p>IGNORE Lone pairs ALLOW O-H displayed or not displayed OR Two arrows from S to O / Dative covalent bonds for the double bonds</p> | | (1) |

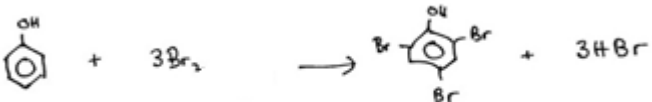
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--------|------------|
| 17a(vi) | Sodium hydroxide/ NaOH/ Sodium carbonate/ Na ₂ CO ₃ / Sodium hydrogencarbonate/ NaHCO ₃ | Na | (1) |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--|------------|
| *17b(i) | <p>There are (strong) London forces between molecules of C₆H₅R</p> <p>and</p> <p>(strong) hydrogen bonds between water molecules (1)</p> <p>(Formation of) London forces between C₆H₅R and water...</p> <p>....do not compensate for energy needed to break bonds</p> <p>ORtoo weak to break London forces/ hydrogen bonds</p> <p>OR Just</p> <p>London forces between C₆H₅R and water are too weak</p> <p>OR</p> <p>Hydrogen bonds cannot form between the two substances (1)</p> <p>IGNORE</p> <p>Hydrophobic/ hydrophilic comments</p> | <p>Dipole-dipole forces</p> <p>Hydrogen bonds in C₆H₅R</p> | (2) |

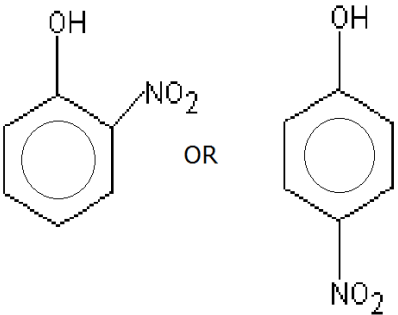
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 17b(ii) | <p>M1 The detergent contains an ionic group</p> <p>OR</p> <p>Detergent contains —SO_3^- and Na^+ ions (1)</p> <p>M2 Energy released when ions are hydrated compensates for energy needed to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

(Total for Question 17= 13 marks)

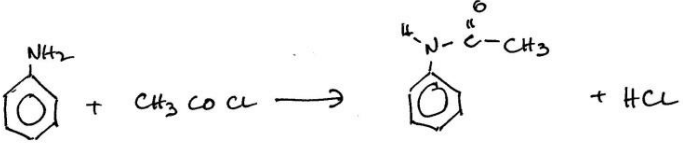
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 18a(i) |  <p>ALLOW $C_6H_6(l) + Br_2(l) \rightarrow C_6H_5Br(l) + HBr(g)$</p> <p>M1 Equation (1)</p> <p>M2 State symbols (1)</p> <p>IGNORE catalysts unless UV</p> | | (2) |

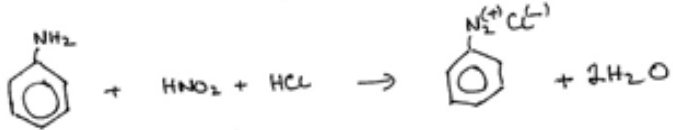
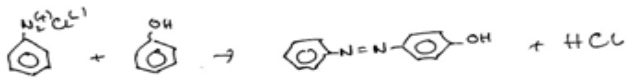
| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 18a(ii) |  <p>IGNORE State symbols even if incorrect</p> | | (1) |

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

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

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

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 18c | <p style="text-align: center;">  </p> <p>Balanced equation (1)</p> <p>Displayed structure of product</p> <p>ALLOW</p> <p>Undisplayed methyl group/ NH group (1)</p> <p>Kekule or delocalised ring</p> | | (2) |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|------------|
| 18d | <p>M1 First step:</p>  <p>OR</p> $\text{C}_6\text{H}_5\text{NH}_2 + \text{HNO}_2 + \text{HCl} \rightarrow \text{C}_6\text{H}_5\text{N}_2^+ \text{Cl}^- + 2\text{H}_2\text{O}$ <p>ALLOW $\text{HNO}_2 + \text{HCl}$ above arrow</p> <p>OR</p> $\text{C}_6\text{H}_5\text{NH}_2 + \text{NaNO}_2 + 2\text{HCl} \rightarrow \text{C}_6\text{H}_5\text{N}_2^+ \text{Cl}^- + 2\text{H}_2\text{O} + \text{NaCl}$ <p>OR</p> <p>Displayed</p> <p>OR</p> <p>Using H^+ /any strong acids eg $\text{C}_6\text{H}_5\text{NH}_2 + \text{HNO}_2 + \text{H}^+ \rightarrow \text{C}_6\text{H}_5\text{N}_2^+ + 2\text{H}_2\text{O}$ (1)</p> <p>M2 Conditions</p> <p>Temperature between 0°C and 10°C / below 10°C (1)</p> <p>M3 Second step:</p>  <p>$\text{C}_6\text{H}_5\text{N}_2^+ \text{Cl}^- + \text{C}_6\text{H}_5\text{OH} \rightarrow \text{C}_6\text{H}_5\text{N}=\text{NC}_6\text{H}_4\text{OH} + \text{HCl}$</p> <p>ALLOW</p> <p>$\text{C}_6\text{H}_5\text{N}_2^+ + \text{C}_6\text{H}_5\text{OH} \rightarrow \text{C}_6\text{H}_5\text{N}=\text{NC}_6\text{H}_4\text{OH} + \text{H}^+$ Substitution on any part of the benzene ring (1)</p> <p>NOTE Diazonium ion may be shown as $\text{N}=\text{N}^+$ or with triple bond in any of these steps and in dye can be N_2 IGNORE Position of plus sign</p> <p>Mark independently</p> | | (3) |

(Total for Question 18= 14 marks)

Section C

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

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

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---------------------|------------|
| 19b(ii) | $2\text{CrO}_3 + \text{H}_2\text{O} \rightarrow \text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+$ OR $2\text{CrO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{Cr}_2\text{O}_7$ ALLOW $\text{CrO}_3 + \text{H}_2\text{O} \rightarrow \text{CrO}_4^{2-} + 2\text{H}^+$ OR $\text{CrO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{CrO}_4$ IGNORE state symbols even if incorrect | Chromium hydroxides | (1) |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|------------|
| 19b(iii) | $\text{Cr}_2\text{O}_7^{2-} + 2\text{OH}^- \rightarrow 2\text{CrO}_4^{2-} + \text{H}_2\text{O}$ ALLOW Na or K ions for both dichromate and hydroxide Reversible arrows IGNORE state symbols even if incorrect | $\text{Cr}_2\text{O}_7^{2-} + \text{OH}^- \rightarrow 2\text{CrO}_4^{2-} + \text{H}^+$ OR $\text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O} \rightarrow 2\text{CrO}_4^{2-} + \text{H}^+$ | (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 $\text{Cr}_2\text{O}_7^{2-}$ at start = $((100 \times 0.0210)/1000)$ = $2.10 \times 10^{-3} / 0.00210$ IGNORE SF except 1 SF | | (1) |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|--------|------------|
| 19(c)(iv) | <p>M1 Mol Fe^{2+} = $((25 \times 0.015)/1000)$ $= 3.75 \times 10^{-4} / 0.000375$ (1)</p> <p>M2 Mol $\text{Cr}_2\text{O}_7^{2-}$ = $((3.75 \times 10^{-4})/6)$ $= 6.25 \times 10^{-5}$</p> <p>OR their mol $\text{Fe}^{2+}/6$ (1)</p> <p>M3 Mol in 200cm^3 solution after reaction $= ((6.25 \times 10^{-5}) \times 200/18.6)$ $= 6.72 \times 10^{-4} / 0.000672$</p> <p>OR their mol in 200cm^3 solution may well be their mol x 8 (1)</p> <p>Mol used in reaction = $((2.1 \times 10^{-3}) - (6.72 \times 10^{-4}))$ $= 1.427957 \times 10^{-3} / 0.00142797$</p> <p>OR their TE subtraction (1)</p> <p>TE on each step</p> <p>For example using 18.6 for volume in M1 (loses M1) gives</p> <p>2.79×10^{-4}</p> <p>M2 4.65×10^{-5}</p> <p>M3 3.72×10^{-4}</p> <p>M4 1.73×10^{-3}</p> <p>IGNORE</p> <p>SF except 1 SF unless already penalised</p> | | (4) |

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