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# Mark Scheme (Results)

January 2017

Pearson Edexcel
International Advanced Subsidiary Level
in Chemistry (WCH05)
Paper 01 General Principles of Chemistry II –
Transition Metals
and Organic Nitrogen Chemistry
(including synoptic assessment)

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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

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## 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.

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**Section A (multiple choice)**

| Question Number | Correct Answer | Mark |
|---|---|---|
| **1** | D | **1** |
| | Incorrect answers<br>A – gradual increase in ionisation energies<br>B – gradual increase in ionisation energies<br>C – gradual increase in ionisation energies | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **2** | A | **1** |
| | Incorrect answers<br>B – ionic is incorrect<br>C – dative covalent is missing<br>D – covalent is missing | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **3** | D | **1** |
| | Incorrect answers<br>A – precipitate is soluble in excess sodium hydroxide<br>B – gives a blue precipitate<br>C – precipitate does not dissolve in excess aqueous ammonia | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **4** | D | **1** |
| | Incorrect answers<br>A – incorrect type of reaction<br>B – incorrect type of reaction<br>C – incorrect type of reaction | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **5** | B | **1** |
| | Incorrect answers<br>A – basic is missing<br>C – acidic is missing<br>D – these are not redox reactions | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **6** | B | **1** |
| | Incorrect answers<br>A – incorrect number of hydrogen atoms<br>C – incorrect number of hydrogen atoms<br>D - incorrect number of hydrogen atoms | |

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| Question Number | Correct Answer | Mark |
|---|---|---|
| **7** | A | **1** |
| | Incorrect answers<br>B – substitution is incorrect<br>C – electrophilic is incorrect<br>D – electrophilic and substitution are both incorrect | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **8** | B | **1** |
| | Incorrect answers<br>A – does not use the concentration<br>C – solution is not alkaline<br>D – solution is not alkaline | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **9** | B | **1** |
| | Incorrect answers<br>A – does not use the concentration<br>C – does not use the concentration and no square root<br>D – no square root | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **10** | C | **1** |
| | Incorrect answers<br>A – no benzene ring<br>B – no benzene ring and no amine<br>D – no amine | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **11** | D | **1** |
| | Incorrect answers<br>A – can form an amine<br>B – can form an amine<br>C – can form an amine | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **12** | B | **1** |
| | Incorrect answers<br>A – incorrect volume of oxygen<br>C – incorrect volume of oxygen<br>D - incorrect volume of oxygen | |

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| Question Number | Correct Answer | Mark |
|---|---|---|
| **13** | C | **1** |
| | Incorrect answers<br>A – not used mole ratio<br>B – incorrect mole ratio<br>D – incorrect mole ratio | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **14** | A | **1** |
| | Incorrect answers<br>B – incorrect statement<br>C – incorrect statement<br>D - incorrect statement | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **15** | C | **1** |
| | Incorrect answers<br>A – refluxing is incorrect<br>B – washing is incorrect<br>D – steam distillation is missing | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **16** | A | **1** |
| | Incorrect answers<br>B – incorrect electrode<br>C – incorrect process<br>D – incorrect electrode and process | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **17** | A | **1** |
| | Incorrect answers<br>B – incorrect value<br>C – incorrect sign<br>D – incorrect value and sign | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **18** | B | **1** |
| | Incorrect answers<br>A – Q is not feasible<br>C – Q and R are not feasible<br>D – Q is not feasible | |

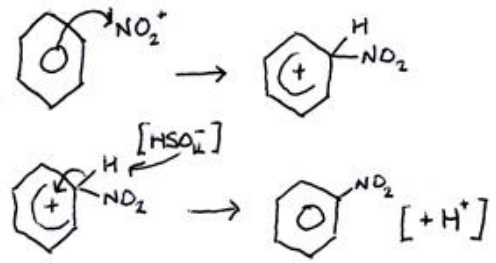
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| Question Number | Correct Answer | Mark |
|---|---|---|
| **19** | C | **1** |
| | Incorrect answers<br>A – burette error not multiplied by 2<br>B – burette error not multiplied by 2 and pipette error should not be multiplied by 2<br>D - pipette error should not be multiplied by 2 | |

| Question Number | Correct Answer | Mark |
|---|---|---|
| **20** | D | **1** |
| | Incorrect answers<br>A – incorrect value (2 mol HCl and 1 mol $H_2SO_4$ formed so 4 mol NaOH needed)<br>B – incorrect value<br>C – incorrect value | |

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**Section B**

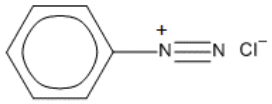
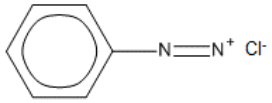
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(a)(i)** | **First mark**<br>$H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_2O + HSO_4^-$<br>**OR**<br>$H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ **and**<br>$H_2NO_3^+ \rightarrow NO_2^+ + H_2O$<br>**OR**<br>$2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$<br>IGNORE state symbols, even if incorrect<br>IGNORE ⇌ **(1)**<br><br><br>**Second mark**<br>Curly arrow from on or within the circle towards N of $NO_2^+$<br>ALLOW curly arrow from anywhere **within** the hexagon<br>ALLOW curly arrow to any part of the $NO_2^+$, including to the + charge<br>ALLOW $NO_2$ with no charge if M1 not awarded, but no other electrophile **(1)**<br>**Third mark – stand alone**<br>Intermediate structure including charge with horseshoe covering at least 3 carbon atoms<br>**and** facing the tetrahedral carbon<br>**and** some part of the positive charge must be within the horseshoe<br>ALLOW dashed line for horseshoe **(1)**<br>**Fourth mark – stand alone**<br>Curly arrow from C-H bond to anywhere in the hexagon reforming the delocalised structure **(1)**<br>Correct Kekulé structures score full marks<br>IGNORE any involvement of $HSO_4^-$ in the final step | Curly arrow on or outside the hexagon<br><br>Dotted bonds to H and $NO_2$ unless clearly part of a 3D structure | **4** |

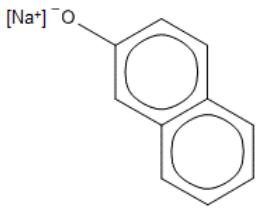
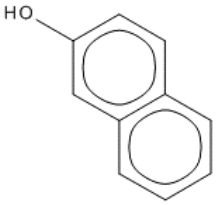
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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(a)(ii)** | Tin/Sn<br>**and**<br>(concentrated) hydrochloric acid /(concentrated) HCl((aq))<br><br>ALLOW<br>Iron/Fe<br>**and**<br>(concentrated) hydrochloric acid /(concentrated) HCl((aq))<br><br>ALLOW<br>**then** sodium hydroxide /NaOH /alkali<br><br>IGNORE mention of catalyst | Dilute /<br>Sulfuric acid /<br>Zinc<br><br>$LiAlH_4$ | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(a)(iii)** | Benzenediazonium chloride / product / nitrous acid / $HNO_2$ decomposes<br><br>ALLOW<br>unstable for decomposes<br><br>**OR**<br>Phenol would form<br><br>ALLOW benzenediazonium chloride undergoes hydrolysis<br><br>IGNORE just forms another product / further substitution / compound is volatile | Nitrobenzene / phenylamine decomposes | **1** |

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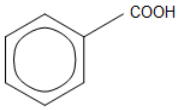
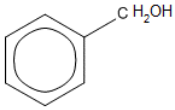
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(a)(iv)** | <br>**OR**<br><br>Must show + charge, this can be on either nitrogen, between the nitrogens or outside of brackets around the cation<br>**and** bonds around N<br>**and** separate $Cl^-$ ion<br><br>IGNORE bond angles<br><br>Correct Kekulé structure scores the mark | Bond between N and Cl | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(a)(v)** | **OR**<br> <br>ALLOW NaO−, provided there is no bond between Na and O<br><br>IGNORE connectivity of OH if the bond is vertical<br><br>Correct Kekulé structure scores the mark | OH−C<br><br>ONa−C | **1** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **21(b)** | **Stand alone marks**<br>If name and formula are given, both must be correct<br><br>$CH_3Cl$ / chloromethane<br>**OR**<br>$CH_3Br$ / bromomethane<br>**OR**<br>$CH_3I$ / iodomethane **(1)**<br><br>(Dry) aluminium chloride / $AlCl_3$ / iron(III) chloride / $FeCl_3$<br>**OR**<br>(Dry) aluminium bromide / $AlBr_3$ / iron(III) bromide / $FeBr_3$<br>**OR**<br>(Dry) aluminium iodide / $AlI_3$ / iron(III) iodide / $FeI_3$ **(1)**<br><br>IGNORE heat / reflux /other conditions | Addition of acid / alkali / water | **2** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| ***21(c)** | IGNORE unbalanced equations / additional incorrect species in equations throughout the answer<br><br>**Oxidation**<br>Potassium dichromate((VI)) / $K_2Cr_2O_7$ / $Cr_2O_7^{2-}$<br>**and**<br>(dilute) sulfuric acid / $H^+$ / acidified(aq) (heat /reflux)<br><br>ALLOW other oxidizing agents eg $KMnO_4/H^+$(aq) / Fehling's / Benedict's / Tollens'<br>IGNORE concentration of acid **(1)**<br><br>**Intermediate** – stand alone<br><br><br>ALLOW $-CO_2H$ and displayed/ skeletal formula **(1)**<br><br>**Reduction** – of benzaldehyde or benzoic acid<br>Lithium tetrahydridoaluminate((III)) / lithium aluminium hydride /$LiAlH_4$<br>**and**<br>(dry) ether / ethoxyethane / $(C_2H_5)_2O$<br><br>ALLOW sodium tetrahydridoborate(III) / sodium borohydride / $NaBH_4$<br>**and**<br>water / aq **(1)**<br><br>**Intermediate** – stand alone<br><br><br>ALLOW displayed/ skeletal formula<br>IGNORE name, even if incorrect **(1)**<br><br>**Esterification**<br>**EITHER**<br>React benzoic acid and phenylmethanol<br>**and**<br>(concentrated) strong acid / hydrochloric acid / HCl / sulfuric acid / $H_2SO_4$ (and heat / reflux)<br>**OR**<br>react benzoic acid with $PCl_5$ / phosphorus(V) chloride<br>**and**<br>react benzoyl chloride and phenylmethanol together (at room temperature) **(1)**<br>IGNORE heat | HCl(aq)<br><br>$PCl_5$(aq) | **5** |

**(Total for Question 21 = 15 marks)**

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(a)(i)** | Sc [Ar] ↑ ↑↓<br>$Mn^{3+}$ [Ar] ↑ ↑ ↑ ↑<br>$Fe^{2+}$ [Ar] ↑↓ ↑ ↑ ↑ ↑<br><br>**OR** half-headed arrows<br><br>Any one row correct scores **(1)**<br>All 3 rows correct scores **(2)** | Vertical lines with no arrow heads once only | **2** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(a)(ii)** | d-block element:<br>(When the electronic structure is built up according to the *aufbau* rules) the **last** electron goes into the d-subshell / (one) of the d orbitals / a d orbital **(1)**<br><br>transition element:<br>Forms / has at least one **ion** with a partially filled / incomplete d-subshell / incomplete d orbital(s)<br><br>ALLOW<br>Forms / has at least one **ion** with an unpaired d-electron / incomplete d orbital(s)<br><br>ALLOW reference to one ion or more than one ion **(1)**<br><br>IGNORE additional properties such as variable oxidation state / forms coloured ions / forms complex ions | Just 'electrons present in d-subshell<br><br>Outer(most) / valence electrons are in d-subshell<br><br>Penalise shell for subshell once only | **2** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(a)(iii)** | **EITHER**<br><br>The paired electron / an electron in the full orbital in (3d in) $Fe^{2+}$ is easily removed due to repulsion<br>ALLOW<br>The paired electron in $Fe^{2+}$ requires less energy (to remove) due to repulsion **(1)**<br><br>But the (3)$d^5$ arrangement / half-filled (3)d-subshell / half-filled (3)d orbitals in $Mn^{2+}$ is stable (so an electron is not easily lost) **(1)**<br><br>**OR**<br><br>$Fe^{3+}$ **and** $Mn^{2+}$ both have (3)$d^5$ arrangement / half-filled (3)d sub-shell / half-filled (3)d orbitals **(1)**<br><br>**Stand alone mark**<br>The half-filled (3)d-subshell / (3)d orbitals is / are (more) stable (than $3d^6$ in $Fe^{2+}$ and $3d^4$ in $Mn^{3+}$) **(1)** | If 'd orbitals' has not been mentioned somewhere in the answer penalise 'half-filled d orbital' in EITHER or OR answers | **2** |

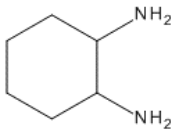
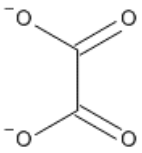
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(a)(iv)** | The energy difference between the (sets / splitting of) (3)d orbitals is different (when water ligands are present)<br><br>ALLOW<br>The splitting of the (3)d orbitals / sub-shell is different **(1)**<br><br>IGNORE just 'they have different energy levels'<br><br>So they absorb different frequencies / wavelengths (of visible light) **(1)**<br><br>IGNORE they have different numbers of d electrons (for d-d transitions)<br><br>IGNORE just 'they absorb different colours / energy' | (3)d orbital, if not penalised in (a)(iii)<br><br>Energy released | **2** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(b)** | **First mark** – comment about As<br>5 mol $As_2O_3$ (oxidised) so the change / increase in oxidation number is 20 / total $20e^-$ lost /<br>$5As_2O_3 + 10H_2O \rightarrow 5As_2O_5 + 20H^+ + 20e^-$ /<br>1 mol $As_2O_3$ loses $4e^-$ / $As_2O_3 + 2H_2O \rightarrow As_2O_5 + 4H^+ + 4e^-$ **(1)**<br><br>**Second mark** – comment about Mn<br>4 mol $MnO_4^-$ (reduced and) change decrease in oxidation number is 20 / total $20e^-$ gained /<br>change in oxidation number of each Mn is 5 / each Mn(VII) gains $5e^-$ **(1)**<br><br>**Third mark** – final oxidation number<br>(final oxidation number is) +2 / $Mn^{2+}$ / Mn(II)<br>**conditional on some working / equation to show this (1)** | | **3** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(c)(i)** | Ligand has 2 atoms that can form (co-ordinate / dative covalent) bonds (to the metal ion)<br><br>ALLOW<br>Has 2 lone pairs that form (co-ordinate / dative covalent) bonds<br><br>ALLOW<br>Has 2 lone pairs that it donates (to the metal ion)<br><br>ALLOW<br>Forms 2 (co-ordinate / dative covalent) bonds (to the metal ion)<br><br>IGNORE mention of nucleophile | 2 ligands attached to the ion<br><br>Ionic bond<br><br>Just 'has 2 lone pairs' | **1** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(c)(ii)** | ALLOW skeletal / displayed / structural formulae or any combination of these<br><br>**(1)**<br><br>ALLOW delocalised $COO^-$ groups **(1)**<br>IGNORE lone pairs | | **2** |

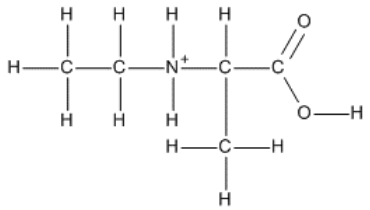
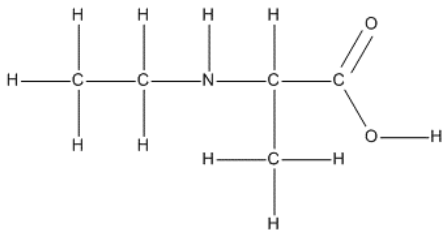
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **22(c)(iii)** | (+)2 / II /2+ | | **1** |

**(Total for Question 22 = 15 marks)**

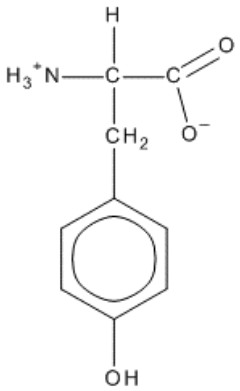
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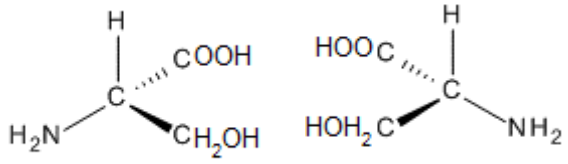
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(a)(i)** | Hydrogen cyanide / HCN (and potassium cyanide / KCN)<br><br>**OR**<br>Potassium cyanide / KCN / sodium cyanide / NaCN<br>**and**<br>pH = 8 / $H_2SO_4$ / HCl<br><br>IGNORE<br>concentrations of acids<br>alkali | Just $CN^-$ | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(a)(ii)** | any named strong acid / HCl / $H_2SO_4$ / $H^+$<br><br>**OR**<br><br>any named strong alkali / NaOH / KOH /$OH^-$ **followed by** an acid<br><br>IGNORE water / concentrations of solutions | Just 'acid'<br><br><br><br>alkali and acid added at the same time | **1** |

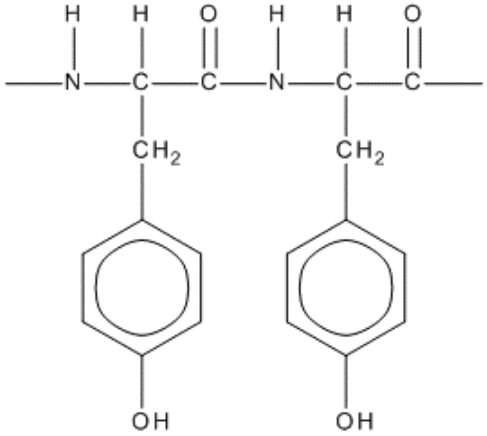
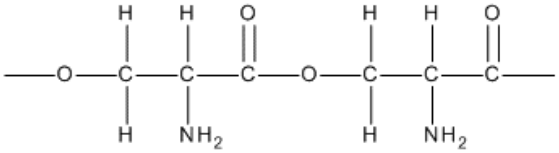
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(a)(iii)** | <br>($Cl^-$)<br><br>**OR**<br><br><br><br>**OR** formation of tertiary or quaternary amines<br><br>ALLOW $CH_3$ / $C_2H_5$<br><br>ALLOW OH<br><br>ALLOW zwitterions for secondary / tertiary amines | | **1** |

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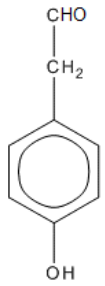
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(b)(i)** | <br>ALLOW positive charge anywhere on $NH_3$<br>ALLOW delocalised $COO^-$ group<br>ALLOW structural / displayed / skeletal formulae or any combination of these<br>IGNORE connectivity of OH group / $NH_3^+$ | Negative charge on O of phenol | **1** |

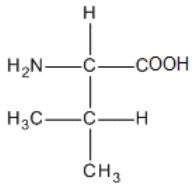
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(b)(ii)** | <br>1 structure with 4 atoms / groups in any order **(1)**<br>Structure on right is mirror image of structure on left **(1)**<br>ALLOW zwitterions | | **2** |

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| Question Number | Acceptable Answers | Mark |
|---|---|---|
| **23(b)(iii)** | ALLOW displayed / skeletal / structural formulae or any combination of these apart from the **linkages which must be displayed**<br><br>IGNORE brackets and n / bond angles<br><br>Polyamide<br><br><br>1 correct displayed amide group in any polyamide **(1)**<br><br>rest of structure correct<br>conditional on an amide group - allow this even if amide group is not displayed<br><br>ALLOW -CO-NH- at start / –CO-NH- at end, but do not allow NH at both ends **(1)**<br><br>Polyester<br><br><br>1 correct displayed ester group in any polyester **(1)**<br><br>rest of structure correct<br>conditional on an ester group - allow this even if ester group is not displayed<br><br>ALLOW –O-CO- at start / -CO-O- at end, but do not allow the single bond Os at both ends **(1)** | **4** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(c)(i)** | ALLOW displayed / skeletal / structural formulae or any combination of these<br><br><br>IGNORE connectivity of OH | | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(c)(ii)** | ALLOW displayed / skeletal / structural formulae or any combination of these e.g<br>$(CH_3)_2CHCH(NH_2)COOH$ /<br><br><br>ALLOW zwitterion | | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(d)** | Yes, because<br>**EITHER**<br>the C-H stretching is different in alkanes and arenes / benzene<br>**OR**<br>tyrosine has an absorption at 3030 ($cm^{-1}$) and serine does not<br><br>**OR**<br>No, because the broad OH absorption from COOH / (the carboxylic) acid would overlap / mask the different C-H absorptions<br><br>IGNORE mention of absorptions below 2000 ($cm^{-1}$) | | **1** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **23(e)(i)** | 5 / five (environments) | | **1** |

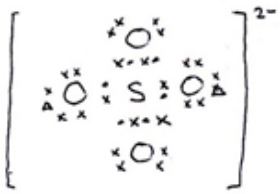
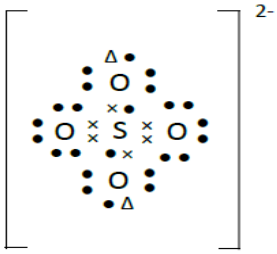
| Question Number | Acceptable Answers | Mark |
|---|---|---|
| **23(e)(ii)** | **For 'chemical shift' column, allow any range or any single value within range and allow range in the opposite order**<br>e.g 3.5 - 2.3<br><br>IGNORE multiplet | **3** |

| Protons in valine | Chemical shift / ppm for TMS | Splitting pattern |
|---|---|---|
| **$CH_3$** | 0.1-1.9 | **doublet / (splits into) 2 (1)** |
| **CH** | 0.1-1.9 | **octet / octuplet/ (splits into) 8 (1)** |
| **OH** | **10(.0)-12(.0) (1)** | singlet |

**(Total for Question 23 = 17 marks)**

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**Section C**

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(a)(i)** | ALLOW any combination of dots and crosses and just dots or just crosses<br><br>ALLOW any other symbol for extra electrons eg *<br><br>ALLOW overlapping circles with electrons in correct places<br><br>IGNORE missing brackets and charge<br><br><br><br>2 double bonds and 2 single bonds **(1)**<br><br>Rest of diagram correct<br>Conditional on M1 **(1)**<br><br>IGNORE other diagrams, such as displayed formula<br><br>IGNORE shape<br><br>ALLOW<br>4 single bonds between S and O **(1)**<br><br><br><br>Rest of diagram correct<br>Conditional on M1 **(1)** | 4 double bonds | **2** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(a)(ii)** | Tetrahedral<br><br>ALLOW triangular based pyramidal<br><br>IGNORE pyramidal | | **1** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(a)(iii)** | Correct answer with no working scores **(2)** marks<br><br>**EITHER**<br>mass of $PbSO_4$ dissolved in 250.0 $cm^3$<br>$= 1.26 \times 10^{-4} \times 303.3 \times \frac{250.0}{1000}$<br>**$= 9.55395 \times 10^{-3}$ (g)** **(1)**<br><br>mass undissolved $PbSO_4$<br>$= 0.0500 - 9.55395 \times 10^{-3}$<br>**= 0.040446 / 0.04045/ 0.0404 / 0.04(0) (g) (1)**<br>TE on mass dissolved in 250.0 $cm^3$<br><br>**OR**<br>mol $PbSO_4$ added = $\frac{0.0500}{303.3} = 1.6485 \times 10^{-4}$<br>**and**<br>mol $PbSO_4$ dissolved in 250 $cm^3$<br>$= 1.26 \times 10^{-4} \times \frac{250.0}{1000}$<br>**$= 3.15 \times 10^{-5}$** **(1)**<br><br>mol undissolved $PbSO_4$<br>$= 1.6485 \times 10^{-4} - 3.15 \times 10^{-5}$<br>$= 1.3335 \times 10^{-4}$<br>**and**<br>mass undissolved $PbSO_4$<br>$= 1.3335 \times 10^{-4} \times 303.3$<br>**= 0.040446 / 0.04045 / 0.0404 / 0.04(0) (g) (1)**<br>TE on mol dissolved in 250 $cm^3$ | | **2** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(b)(i)** | $Na_2S_2O_7 \rightarrow Na_2SO_4 + SO_3$<br><br>ALLOW multiples<br><br>IGNORE state symbols, even if incorrect | | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(b)(ii)** | $(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2O$<br><br>ALLOW multiples<br><br>IGNORE state symbols, even if incorrect | | **1** |

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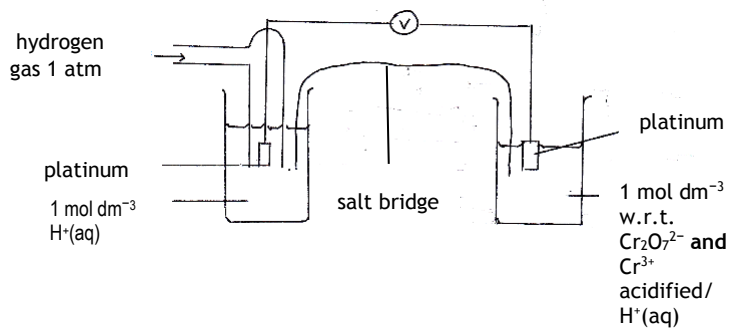
| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(c)(i)** | $CrO_4^{2-}(aq) + 4H_2O(l) + 3e^{(-)} \rightleftharpoons Cr(OH)_3(s) + 5OH^-(aq)$<br>**and**<br>−0.13 (V)<br><br>ALLOW →<br><br>IGNORE missing state symbols<br><br>IGNORE square brackets around $Cr(OH)_3$ | Half-cell | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(c)(ii)** | $FeO_4^{2-}(aq)$ / $FeO_4^{2-}$ | Additional species | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(c)(iii)** | $3MnO_4^{2-}(aq) + 2H_2O(l) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 4OH^-(aq)$<br><br>State symbols **are** required | | **1** |

| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(c)(iv)** | (+)0.83 (V) / .83 (V) | −0.83 (V) | **1** |

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| Question Number | Acceptable Answers | Mark |
|---|---|---|
| **24(c)(v)** | <br>ALLOW half-cells reversed<br><br>**Hydrogen half-cell:**<br>Solution 1 mol dm$^{-3}$ H$^+$(aq) **and** platinum (black) electrode<br><br>ALLOW<br>1 mol dm$^{-3}$ hydrochloric acid / HCl / nitric acid / $HNO_3$<br><br>ALLOW 0.5 mol dm$^{-3}$ sulfuric acid **(1)**<br><br>Hydrogen gas at 1 atm / 1.01 x $10^5$ Pa / 100 kPa pressure / 1 bar **(1)**<br><br>**Chromium half-cell:**<br>Solution 1 mol dm$^{-3}$ / equimolar with respect to dichromate / $Cr_2O_7^{2-}$ ions **and** chromium(III) / $Cr^{3+}$ ions (in the same beaker) **(1)**<br><br>Acidified / H$^+$(aq) / HCl IGNORE concentration of acid<br>**and**<br>platinum electrode **(1)**<br><br>**Connections:**<br>Salt bridge dipping into both solutions<br>**and** voltmeter to measure Standard Electrode Potential<br>**and** complete circuit<br><br>ALLOW a salt bridge drawn and just labelled with the electrolyte<br><br>Do not award this mark if the circuit is incorrect, e.g a cell is included. Ignore ammeter. **(1)** | **5** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| **24(d)(i)** | 6 : 1<br><br>OR<br><br>$\frac{6}{1}$<br><br>ALLOW<br><br>$Cr_2O_7^{2-}$ : $S_2O_3^{2-}$ = 1 : 6 / $\frac{1}{6}$<br><br>IGNORE all working | | **1** |

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| Question Number | Acceptable Answers | Reject | Mark |
|---|---|---|---|
| ***24(d)(ii)** | Correct answer with no working scores **(6)**<br><br>**M1** mol $S_2O_3^{2-}$ = 0.030 x 9.20/1000<br>= **$2.76 \times 10^{-4}$** **(1)**<br><br>**M2** mol $Cr_2O_7^{2-}$ left = $2.76 \times 10^{-4}/6$ = **$4.60 \times 10^{-5}$**<br>**OR**<br>mol $I_2$ = $2.76 \times 10^{-4}/2 = 1.38 \times 10^{-4}$<br>**and**<br>mol $Cr_2O_7^{2-}$ left = $1.38 \times 10^{-4}/3 = 4.60 \times 10^{-5}$<br>TE on mol ratio in (i) **(1)**<br><br>**M3** original mol $Cr_2O_7^{2-}$ = 0.015 x 10.0/1000<br>= **$1.50 \times 10^{-4}$** **(1)**<br><br>**M4** mol $Cr_2O_7^{2-}$ reacted with $C_2H_5OH$<br>= $1.50 \times 10^{-4} - 4.60 \times 10^{-5}$<br>= $1.04 \times 10^{-4}$<br>**and**<br>mol $C_2H_5OH$ in 1.00 $cm^3$ diluted wine<br>= $1.04 \times 10^{-4}$ x 3/2<br>= **$1.56 \times 10^{-4}$**<br>TE on original mol $Cr_2O_7^{2-}$ and mol $Cr_2O_7^{2-}$ reacted with $C_2H_5OH$ **(1)**<br><br>**M5** mol $C_2H_5OH$ in 100 $cm^3$ diluted wine / 5.00 $cm^3$ original wine<br>= $1.56 \times 10^{-4} \times 100$ = **$1.56 \times 10^{-2}$**<br>TE on mol $C_2H_5OH$ in 1.00 $cm^3$ diluted wine **(1)**<br><br>**M6** mass $C_2H_5OH$ in 5.00 $cm^3$ original wine<br>= $1.56 \times 10^{-2}$ x 46<br>= **0.7176** / **0.718** / **0.72** (g)<br>TE on mol $C_2H_5OH$ in 100 $cm^3$ diluted wine/5.00 $cm^3$ original wine **(1)**<br><br>IGNORE SF except 1 SF | | **6** |

**(Total for Question 24 = 23 marks)**

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