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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH05) Paper 01

General Principles of Chemistry II Transition Metals and Organic 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. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

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	Reject	Mark
1	D		**1**
2	C		**1**
3	A		**1**
4(a)	D		**1**
4(b)	A		**1**
5(a)	C		**1**
5(b)	D		**1**
5(c)	C		**1**
6	B		**1**
7	A		**1**
8	D		**1**
9(a)	D		**1**
9(b)	A		**1**
9(c)	D		**1**
9(d)	C		**1**
10(a)	B		**1**
10(b)	B		**1**
11(a)	B		**1**
11(b)	D		**1**
11(c)	A		**1**
		Total for section A	**20 marks**

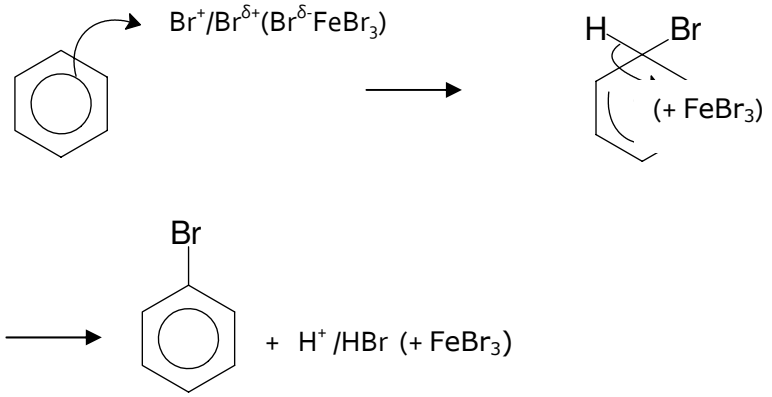
Section B

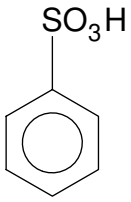
Question Number	Acceptable Answers	Reject	Mark
12(a)(i)	(3 x -120) = -360 (kJ mol^{-1}) IGNORE ∆H, and case of letters in units e.g allow Kj	No sign or + sign in answer, ie 360/+360 Any other wrong units ∆E	**1**

Question Number	Acceptable Answers	Reject	Mark
***12(a)(ii)**	• (Bonding in) benzene/it is more **stable** (than Kekule) by **152** kJ mol^{-1} (consequential on (a)(i)) **(1)** IGNORE sign • **π /p/double bond electrons** are delocalized (around the ring) OR six **p electrons** shared between six (ring) carbon atoms OR delocalized because of overlap of **p orbitals** OR resonance hybrid of C=C's and C-C's **(1)** • **Substitution** reactions (rather than addition) **(1)** NOTE: **Nucleophilic** substitution negates the substitution mark because it is wrong additional information • Maintains/regains delocalized system OR maintains/regains stability OR maintains/regains stabilization energy **(1)**	Attack by electrophiles with no mention of substitution	**4**

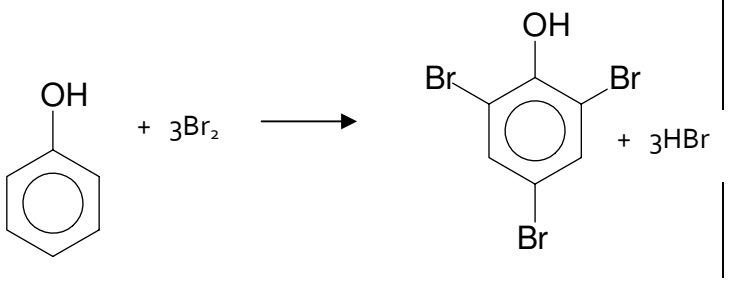
Question Number	Acceptable Answers	Reject	Mark
12(b)(i)	Concentrated nitric acid/HNO_3 **(1)** Concentrated sulfuric acid/H_2SO_4 **(1)** Allow conc or c. in place of 'concentrated' ALLOW Concentrated nitric acid and sulfuric acid OR Concentrated HNO_3 and H_2SO_4 **(2)** Second mark depends on nitric acid Max. (1) if no mention of concentrated Nitric acid and concentrated sulfuric acid scores (1) NOTE: conc. HNO_3 and H_2SO_4(aq) scores (1) but conc. HNO_3 and conc H_2SO_4(aq) scores (2)	Concentrated hydrochloric acid	**2**

Question Number	Acceptable Answers	Reject	Mark
12(b)(ii)	Electrophile/electrophilic ALLOW Electrophyl(e)	Acid Base Oxidizing agent Reducing agent	**1**

Question Number	Acceptable Answers	Reject	Mark
12(b)(iii)	$Br_2 + FeBr_3 \rightarrow FeBr_4^- + Br^+$ OR $Br\text{-}Br + FeBr_3 \rightarrow Br^{\delta+}\ldots..Br^{\delta-}FeBr_3$ **(1)** IGNORE state symbols even if wrong  Arrow from benzene ring electrons (from **inside** the hexagon) to $\mathbf{Br^+/Br^{\delta+}}(\ldots..Br^{\delta-}FeBr_3)$ **(1)** Correctly drawn intermediate with delocalization covering at least three carbon atoms, but not the carbon atom bonded to the bromine with the positive charge shown inside the hexagon The bonds to H and Br may be dotted **(1)** Arrow from or close to **bond** to H to centre of ring **and** H^+/HBr as a product **(1)** ALLOW Kekulé structure for benzene and intermediate **Each marking point is independent**	lack of charges	**4**

Question Number	Acceptable Answers	Reject	Mark
12(b)(iv)	 OR $C_6H_5SO_3H$ accept: displayed $-SO_3H$ $-SO_3^-H^+$ $-SO_2OH$ If two formulae are given both must be correct **(1)** Penalise if bond **clearly** goes to O or H rather than S **Benzenesulfonic acid** **(1)** ALLOW **phenyl sulfonic acid**	Benzenesulfuric acid/benzosulfonic acid/benzylsufonic acid	**2**

Question Number	Acceptable Answers	Reject	Mark
12(c)(i)	**Non-bonding/lone pair** electron**s** from **oxygen**... **(1)** ...are delocalized/incorporated/donated into the ring (electron system) (Could be shown in diagram) OR increases electron density on the ring **(1)** makes it (the ring) more susceptible to electrophilic attack/makes it (the ring) a better nucleophile **(1)**	…from methyl/methoxy Makes it more electronegative	**3**

Question Number	Acceptable Answers	Reject	Mark
12(c)(ii)	 **(1)** organic formula **(1)** balancing ALLOW • Condensed structural formulae, for example $C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$ **(1)** **(1)** balancing • multiples • substitution to any positions IGNORE: H_2O Position of bond to OH NOTE: Correct balanced equations giving mono and disubstitution phenols score **1 mark**		**2**

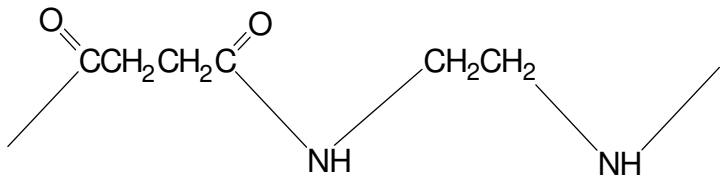
Question Number	Acceptable Answers	Reject	Mark
12(d)	(Chloromethyl)benzene/chloromethylbenzene/ chlorophenylmethane/ benzyl chloride OR dichloromethane **(1)** ALLOW phenylchloromethane Aluminium chloride **(1)** ACCEPT formulae eg C_7H_7Cl, $C_6H_5CH_2Cl$, CH_2Cl_2, $AlCl_3$ ACCEPT other halogen carriers eg $FeCl_3$/iron**(III)** chloride/$ZnCl_2$ ACCEPT bromine in place of chlorine for either/both marks Correct formula and wrong name or correct name and wrong formula or any other wrong additional information loses mark	CH_2Cl	**2**

Question Number	Acceptable Answers	Reject	Mark
13(a)	$H_2NCH_2CH_2NH_2 + 2HCl \rightarrow H_3N^+CH_2CH_2NH_3^+ + 2Cl^-$ **(1)** organic product Positive charges can be on nitrogens Balancing with **HCl** and **Cl^-** **(1)** Chloride ions can be at ends of product ie $ClH_3NCH_2CH_2NH_3Cl$ for right hand side, with or without charges, but if given charges must balance $H_2NCH_2CH_2NH_2 + 2H^+ \rightarrow H_3N^+CH_2CH_2NH_3^+$ **(2)** Reaction with 1 mol HCl for 1 max If molecular formulae used 1 max IGNORE state symbols even if wrong	Covalent bond to Cl, (-Cl)	**2**

Question Number	Acceptable Answers	Reject	Mark
13 (b)(i)	Blue or green or blue-green or lavender ALLOW qualification of blue or green e.g. dark blue, but not with another colour e.g. blue purple	Any other colour e.g. Purple Violet	**1**

Question Number	Acceptable Answers	Reject	Mark
13(b)(ii)	The entropy change of the **system** is positive **(1)** Because there is an increase in the number of particles/entities/moles/molecules OR The number of particles/entities/moles goes from four to seven OR Complex with three molecules goes to a complex with six molecules **(1)** Second mark depends on a positive entropy change	Additional incorrect numbers molecules/ atoms from four to seven	**2**

Question Number	Acceptable Answers	Reject	Mark
13(b)(iii)	They will **rotate** the **plane of plane-** polarised light (equally in opposite directions) Allow They will **rotate** the **plane** of polarised light (equally in opposite directions) OR They will **rotate plane-** polarised light (equally in opposite directions)	Optically active Reflect/ bend/ refract	**1**

Question Number	Acceptable Answers	Reject	Mark
13(c)(i)	 Amide linkage correct **(1)** Further detail correct, including trailing bonds **(1)** IGNORE brackets ALLOW multiple units Second mark dependent on correct amide link ALLOW fully correct structural formulae for 1 ~~(~~$OCCH_2CH_2CONHCH_2CH_2NH$~~)~~ Can start with NH group		**2**

Question Number	Acceptable Answers	Reject	Mark
13(c)(ii)	Condensation **(1)** Hydrogen chloride/HCl/water/H_2O or another **small** molecule/is produced/lost/formed/removed (as well as the polymer) **(1)** Mark independently	Addition/elimination	**2**

Question Number	Acceptable Answers	Reject	Mark
***13(c)(iii)**	**Types of force** Hydrogen bonds **and** (permanent) dipole(-permanent dipole) forces **and** London/van der Waals'/dispersion forces OR Explanation e.g temporary/induced dipoles **(1)** All three needed for 1st mark (which is given even if the forces are later explained incorrectly) **Hydrogen bonds** (Between) the hydrogen atoms on the nitrogen atoms and ... OR (Between) N-H and ... **(1)** ... (the lone pair of electrons on) oxygen/ nitrogen atoms **(1)** These marks can be shown by a diagram **Permanent dipole-permanent dipole forces** Because the C=O / carbon-oxygen bond/the C-N bond is polar/a dipole OR N and/or O are electronegative atoms This mark can be shown by a diagram providing the polarity of the bond is shown **(1)** **London forces** Polymer has large number of/many electrons OR Explanation e.g temporary/induced/fluctuating dipoles **(1)**	Just p.d.- p.d Just v d W Large molecular mass alone	**5**

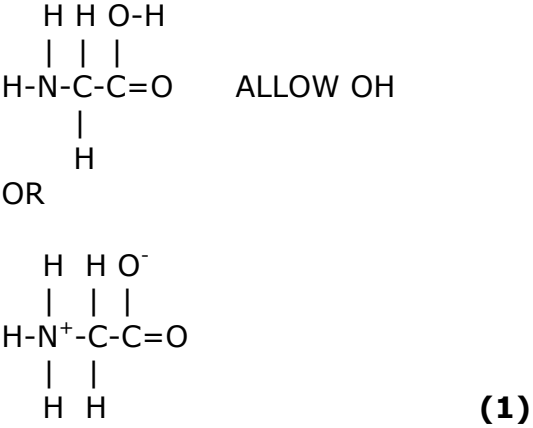
Question Number	Acceptable Answers	Reject	Mark
14(a)	**Route 1 by mol of H, C and N** $\frac{0.072}{18}$ = 0.004 mol water OR 0.008 mol H(atoms) **And** $\frac{0.176}{44}$ = 0.004 mol carbon (dioxide) **(1)** $\frac{24.0}{24000}$ = 0.001 mol nitrogen N_2 OR 0.002 mol N(atoms) **(1)** Mass of H + mass of C + mass of N = 0.008 + 0.004 x 12 + 0.028 **(1)** = 0.084 g mass of oxygen = 0.132 – (0.008 + 0.004 x 12 + 0.028) = 0.048 g amount of oxygen = $\frac{0.048}{16}$ = 0.003 mol **(1)** empirical formula is $C_4H_8O_3N_2$ **(1)** **Route 2 by mass of H, C and O calculated in one step** mass of H = 2/18 x 0.072 = 0.008 g **(1)** mass of C = 12/44 x 0.176 = 0.048 g **(1)** mass of N = 24/24000 x 28 = 0.028 g **(1)** mass of O = 0.132 – (0.008 + 0.048 + 0.028) = 0.048 g moles of O = 0.003 **(1)** moles of H = 0.008		**5**

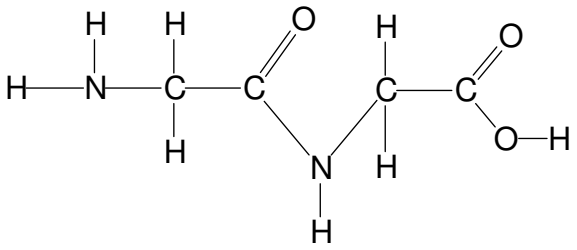
	moles of C = 0.004 moles of N = 0.002 empirical formula is $C_4H_8O_3N_2$ **(1)** **Route 3 Percentage by mass of each element in 0.132 g** First three marks by either method above. Then percentages are: H – 6.06 C – 36.36 N – 21.21 So O is 100 – (6.06 + 36.36 + 21.21) = 100 – 63.63 = 36.37 Mole ratios O – 2.27 – allow = or – 0.02 **(1)** H – 6.06, C – 3.03, N – 1.515 Dividing by smallest gives H – 4, C – 2, N – 1, O – 1.5 empirical formula is $C_4H_8O_3N_2$ **(1)** **The following transferred errors are allowed:** If nitrogen gas taken as N, first two marks can still be awarded for all methods Then mass of nitrogen is 0.014 g This gives mass of oxygen as 0.062 g and amount of oxygen as 0.003875 mol **(1)** now empirical formula is $C_4H_8O_4N$ **(1)** **OR** percentage method: N – 10.61% O – 46.97%		

	Mole ratio N – 0.7575 O – 2.935 **(1)** empirical formula is $C_4H_8O_4N$ **(1)** **Transferred error for hydrogen** Two from first three marks still awarded Then amount of hydrogen is 0.004 mol This gives 0.003125 mol oxygen empirical formula is $C_4H_4O_3N_2$ **(1)** **Both the above nitrogen and hydrogen errors** Award 1 mark for correct mass of carbon or correct moles of carbon Then mass of nitrogen is 0.014 g Then mass of hydrogen is 0.004 g This gives 0.004125 mol oxygen **(1)** Empirical formula is $C_4H_4O_4N$ **(1)**		

Question Number	Acceptable Answers	Reject	Mark
14(b)	**(12 x 4 + 1 x 8 + 16 x 3 + 14 x 2)**n = 132 n = 1 So molecular formula is $C_4H_8O_3N_2$ Some element of working must be shown TE from (a) of nitrogen error can be given **only if**: **(12 x 4 + 1 x 8 + 16 x 4 + 14)**n = 132 n = 0.98 (which is approximately 1) TE from (a) of hydrogen error can be given **only if**: **(12 x 4 + 1 x 4 + 16 x 3 + 14 x 2)**n = 132 n = 1.03 (which is approximately 1) TE from (a) of nitrogen and hydrogen error can be given **only if**: **(12 x 4 + 1 x 4 + 16 x 4 + 14)**n = 132 n = 1.015/1.02 (which is approximately 1)		**1**

Question Number	Acceptable Answers	Reject	Mark
14(c)(i)	**Y** reacts with HCl/acid so it is an amine /contains NH_2 /CO_2^- **(1)** It reacts with alkali/NaOH so it is a carboxylic acid/contains CO_2H/NH_3^+ **(1)** It forms a purple colour/reacts with ninhydrin so it is an amino acid **(1)** OR As it is an amine/contains NH_2 /CO_2^- it will react with HCl/acid **(1)** As it is a carboxylic acid/contains CO_2H/NH_3^+ it will react with alkali/NaOH **(1)** As it is an amino acid so it forms a purple colour/reacts with ninhydrin **(1)** Each marking point is independent and requires both the functional group and the test **NOTE:** It is an amino acid so it reacts with acid and alkali (with neither of first two points) **(1)**	Just ... it is a base Just ... it is an acid ...it is amphoteric (alone)	**3**

Question Number	Acceptable Answers	Reject	Mark
14(c)(ii)	 ALLOW OH OR **(1)** 2-aminoethanoic acid/ aminoethanoic acid/glycine **(1)** Mark independently	C-H-O if bond is clearly to H **1**- aminoethanoic acid	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(iii)	$H_2NCH_2CONHCH_2CO_2H$ Or $NH_2CH_2CONHCH_2CO_2H$ Or $HOCOCH_2NHOCCH_2NH_2$ ALLOW  Or reversed displayed formula ALLOW ionic formulae with H_3N^+ and CO_2^-		**1**

TOTAL FOR SECTION B = 48 MARKS

Question Number	Acceptable Answers	Reject	Mark
15(a)(i)	MnO_2((s))	Anything else eg MnO_4^-	**1**

Question Number	Acceptable Answers	Reject	Mark
15(a)(ii)	• They provide alternative routes/mechanisms for reactions • With lower activation energies/E_a OR catalysts lower activation energy /E_a • So a greater proportion of /more particles/reactants have sufficient energy/E_a (to react)/greater frequency of/more successful collisions All three points **2** any two points **1** All points stand alone and can be in any order IGNORE references to adsorption/surfaces Provide alternate route with lower activation energy scores one mark NOTE: The term activation energy could be described rather than stated		**2**

Question Number	Acceptable Answers	Reject	Mark
15(a)(iii)	Transition metals form various/variable oxidation states **(1)** They are able to **donate and receive** electrons/they are able to **oxidize and reduce**/they are able to be **oxidized and reduced** /ions contain **partially filled** (sub-)shells of **d electrons** **(1)** ALLOW Energy differences between the oxidation states are small (for second mark) OR Reduce reactant with more positive/higher electrode potential **(1)** Then oxidize reactant with more negative/lower electrode potential **(1)** Or other way round: Oxidize reactant with lower electrode potential etc	They change oxidation state Any mention of providing a surface/adsorption loses second mark Formation of intermediates (alone)	**2**

Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	Two (less stable) oxidation states/one higher and one lower oxidation state of **the same/an element** react to form one(more stable) oxidation state ALLOW The reverse reaction is a disproportionation in which (one oxidation state of) the **same/an element** and it EITHER: reacts to give one higher and one lower oxidation state/two oxidation states OR is both oxidized and reduced **(1)** Correct oxidation states +7 and +4 to +6 Mn(VII) and Mn(IV) to Mn(VI) ALLOW Mn^{7+} and Mn^{4+} to Mn^{6+} **(1)** Mark independently		**2**

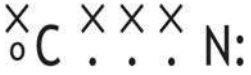
Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	(When the hydroxide ion concentration is increased) the equilibrium (of the second half equation) moves to the left/back **(1)** *E* becomes less positive/more negative/decreases/reduces **(1)** Therefore E_{cell} becomes positive (so reaction feasible) **(1)** ALLOW confusion between E, $E^{\ominus}$, E_{cell} if meaning is clear		**3**

Question Number	Acceptable Answers	Reject	Mark
15(c)(i)	Oxygen/oxygen gas/O_2/O_2(g)	O (alone) Anything else	**1**

Question Number	Acceptable Answers	Reject	Mark
15(c)(ii)	$2MnO_4^-(aq) \rightarrow 2MnO_3^-(aq) + O_2(g)$ Entities **(1)** balancing **(1)** Correct equation with H_2O and/or OH^- on both sides (even if in brackets) max. 1 IGNORE state symbols ACCEPT multiples ACCEPT ⇌ for arrow Reverse equation max. 1 No signs on entities max. 1	Equations including electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
15(c)(iii)	**(Hazard –)** the sodium hydroxide/alkali is corrosive/caustic/burns (skin)/attacks the skin OR attacks the cornea/eye/causes blindness **(1)** IGNORE Harmful/Irritant/toxic/hazardous/concentrated **(Minimize Risk by –)** wear gloves OR (full) eye protection/goggles/safety glasses **(1)** Protection **must** relate to **sodium hydroxide** e.g. sodium hydroxide is irritant so wear gloves / eye protection **scores 1 mark** This means 'This experiment is dangerous so wear eye protection' **score zero** IGNORE lab coats and/or fume cupboards (Oxygen) gas given off so container must not be sealed **(2)**	MnO_4^- is toxic Cl_2 is toxic	**2**

Question Number	Acceptable Answers	Reject	Mark
15(d)	Manganese**(II)**/manganous sulfate (solution) **(1)** ALLOW any named soluble manganese**(II)** salt – chloride, bromide, iodide, nitrate Sodium hydroxide (solution) **(1)** ALLOW any named soluble hydroxide ACCEPT formulae Mark independently except contradiction eg NaOH + HCl (0)	Mn^{2+}(aq) alone Ammonia unless dilute **and** added dropwise	**2**

Question Number	Acceptable Answers	Reject	Mark
15(e)(i)	 Accept dots, crosses, mixture of both Triple bond **(1)** Non-bonding electrons **(1)** IGNORE presence/absence of negative charge But if positive charge max 1 Second mark dependent on first IGNORE correct inner shell electrons on either or both atoms	 If not paired Incorrect inner shell electrons 1 max	**2**

Question Number	Acceptable Answers	Reject	Mark
15(e)(ii)	The non-bonding / lone pair of electrons on the carbon **(1)** ALLOW non-bonding/lone pair of electrons on the nitrogen Forms a **dative covalent/coordinate** bond (to central metal ion) **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
15(e)(iii)	Octahedral/octahedron ALLOW Oct**o**hedral Oct**e**hedral	Tetrahedral/hexagonal/square planar/(trigonal) bipyramid	**1**

TOTAL FOR SECTION C = 22 MARKS

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