
CHEMISTRY

9701/43

Paper 4 A Level Structured Questions

October/November 2017

MARK SCHEME

Maximum Mark: 100

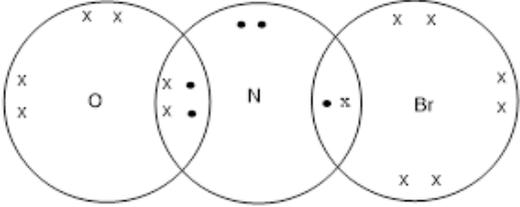
Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

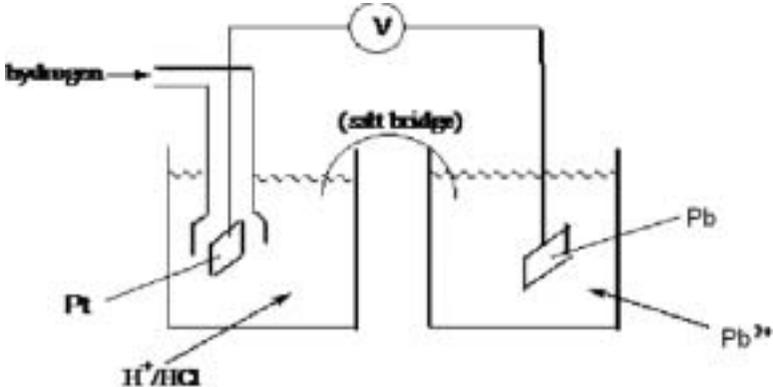
Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2017 series for most Cambridge IGCSE[®], Cambridge International A and AS Level components and some Cambridge O Level components.

| Question | Answer | Marks |
|----------|---|-------|
| 1(a) | N +2 to +3 (and oxidised) | 1 |
| | Br ₂ /Br 0 to -1 (and reduced) | 1 |
| 1(b) |  | |
| | 3 bonding pairs around N (in a structure involving NOBr) | 1 |
| | rest of molecule correct | 1 |
| 1(c)(i) | the power to which a concentration of a reactant is raised in the rate equation | 1 |
| 1(c)(ii) | using expt. 2 and 3 a = 2 or [NO] 2nd order and conc × 3 rate × 9 or $6.1 \times 10^{-2} / 6.8 \times 10^{-3} = (0.09 / 0.03)^a$ | 1 |
| | using expt. 1 and 2 b = 1 or [Br ₂] 1 st order and conc × 2 rate × 2 or $6.8 \times 10^{-3} / 3.4 \times 10^{-3} = (0.04 / 0.02)^b$ | 1 |
| (c)(iii) | initial rate = 0.16(32) | 1 |
| 1(c)(iv) | $(0.0034 = k(0.03)^2(0.02))$ k = 188.9 | 1 |
| | mol ⁻² dm ⁶ s ⁻¹ | 1 |
| 1(c)(v) | k decreases (as rate decreases) | 1 |

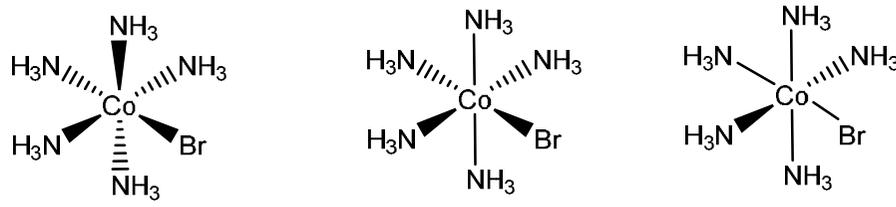
| Question | Answer | Marks |
|----------|---------------------|-------|
| 1(d) | $m = 2$ and $n = 0$ | 1 |

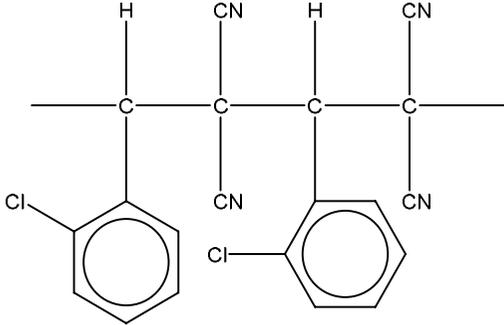
| Question | Answer | Marks |
|-----------|--|-------|
| 2(a) | it/solubility decreases down the group and K_{sp} decreases | 1 |
| 2(b)(i) | $MgCO_3(s) \rightleftharpoons Mg^{2+}(aq) + CO_3^{2-}(aq)$ | 1 |
| 2(b)(ii) | (white) solid appears/precipitation (of $MgCO_3$) | 1 |
| | as $[CO_3^{2-}]$ increases shifting equilibrium to the LHS (precipitating out $MgCO_3$) | 1 |
| 2(c) | solubility = $\sqrt{1.0 \times 10^{-5}} = 3.16 \times 10^{-3} \text{ mol dm}^{-3}$ | 1 |
| | solubility = $3.2 \times 10^{-3} \times 84.3 = 0.27 \text{ g dm}^{-3}$ | 1 |
| 2(d)(i) | Mg^{2+} ion is smaller than Ba^{2+} ion or ionic radii increase down group ora | 1 |
| | (Mg^{2+}) distorts/polarises/the anion/nitrate group/nitrate ion / $NO_3^{(1)-}$ / NO_3 ion more easily (than Ba^{2+}) ora | 1 |
| 2(d)(ii) | $Ba(NO_3)_2 \rightarrow BaO + 2NO_2 + \frac{1}{2}O_2$ | 1 |
| 2(d)(iii) | $BaO + H_2O \rightarrow Ba(OH)_2$ | 1 |
| | $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2H_2O$ | 1 |

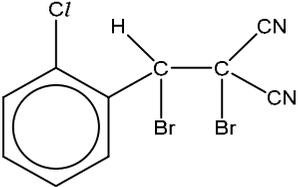
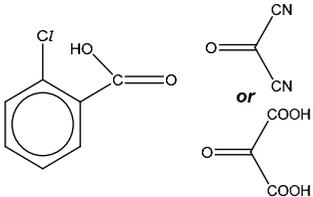
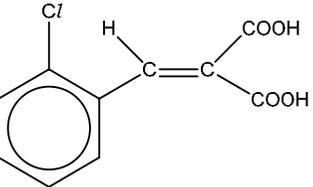
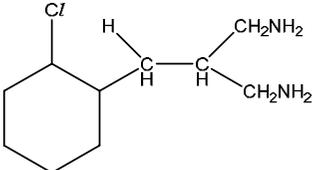
| Question | Answer | Marks |
|----------|---|-------|
| 3(a) | the potential difference between two half-cells / two electrodes (in a cell) | 1 |
| | under standard conditions of 1 atm., 298 K, (all) solutions being 1 mol dm ⁻³ | 1 |
| 3(b)(i) |  <p>8 marking points, any 2 points for each mark</p> <p>H₂ / hydrogen correct delivery system for H₂ Pb²⁺ (aq) Pb electrode Pt electrode H⁺(aq) solution salt bridge voltmeter/V labelled</p> | 4 |
| 3(b)(ii) | more negative | 1 |
| | shifts Pb ²⁺ (+ 2e ⁻) ⇌ Pb equilibrium / reaction to the left | 1 |

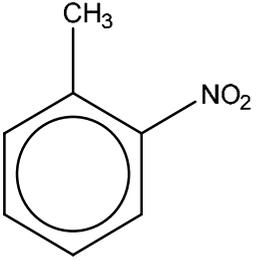
| Question | Answer | Marks |
|----------|---|----------|
| 3(c)(i) | $Q = 0.4 \times 80 \times 60 = \mathbf{1920\ C}$ and use of 96500/193000 Moles of Pb = $1920 / 193000 = 9.95 \times 10^{-3}$ Mass of Pb = $207.2 \times 9.95 \times 10^{-3} = \mathbf{2.1\ g}$ OR $Q = 0.4 \times 80 \times 60 = \mathbf{1920\ C}$ and use of $1.6 \times 10^{-19} / 1.2 \times 10^{22}$ atoms Pb = 6×10^{21} ; moles of Pb = $6 \times 10^{21} / 6 \times 10^{23} = 0.01$ Mass of Pb = $207.2 \times 0.01 = \mathbf{2.1\ g}$ | 2 |
| 3(c)(ii) | $\text{PbO}_2(\text{s}) + \text{SO}_4^{2-}(\text{aq}) + \mathbf{4\ H^+} + \mathbf{2\ e^-} \rightarrow \text{PbSO}_4(\text{s}) + \mathbf{2\ H_2O}$ | 1 |
| 3(d) | reagents/PbO ₂ /H ₂ SO ₄ and used up/concentration decreases | 1 |
| | as fuel/hydrogen is being continuously supplied/fuel has not run out | 1 |

| Question | Answer | Marks |
|----------|--|----------|
| 4(a) | density is higher and melting point is higher | 1 |
| | (density) due to A_r being larger and smaller atomic radii or (Co) atoms/ions heavier and smaller | 1 |
| | (melting point) due to stronger attraction to cations as more delocalised electrons | 1 |
| 4(b) | (a molecule or ion) formed by a central metal atom/ion surrounded by (one or more) ligands | 1 |
| 4(c)(i) | same number and type of <u>atoms</u> and different structural formula | 1 |

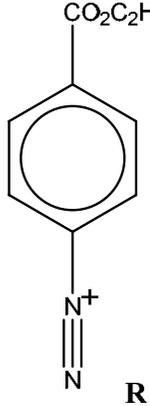
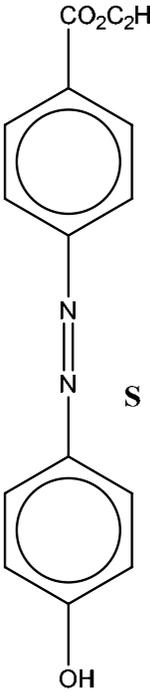
| Question | Answer | Marks | | | | | | | | | | | | | | | |
|---|--|-------------|---------------|-------------|-------------------------|---|--|---|--|---|---|--|---|--|---|--|----------|
| 4(c)(ii) | octahedral AND 3D structure of $[\text{Co}(\text{NH}_3)_5\text{Br}]^{2+}$ e.g. <div style="display: flex; justify-content: space-around; align-items: center; margin-top: 10px;">  </div> | 1 | | | | | | | | | | | | | | | |
| 4(c)(iii) | co-ordinate / dative covalent | 1 | | | | | | | | | | | | | | | |
| 4(c)(iv) | +3 for both | 1 | | | | | | | | | | | | | | | |
| 4(d) | (HNO ₃) Ag ⁺ / AgNO ₃ cream(–yellow) ppt. (of AgBr) and no reaction/white ppt. for other isomer | 1 | | | | | | | | | | | | | | | |
| | Ba(OH) ₂ / Ba ²⁺ (aq) / BaCl ₂ / Ba(NO ₃) ₂ white ppt. (of BaSO ₄) and no reaction for other isomer | 1 | | | | | | | | | | | | | | | |
| 4(e) | (d-d) energy gap / ΔE is different | 1 | | | | | | | | | | | | | | | |
| | absorb different wavelength / frequency (of light) | 1 | | | | | | | | | | | | | | | |
| 4(f) | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 50%;"></th> <th style="width: 25%;">heterogeneous</th> <th style="width: 25%;">homogeneous</th> </tr> </thead> <tbody> <tr> <td>Fe in the Haber process</td> <td style="text-align: center;">✓</td> <td></td> </tr> <tr> <td>Fe²⁺ in the I⁻ / S₂O₈²⁻ reaction</td> <td></td> <td style="text-align: center;">✓</td> </tr> <tr> <td>NO₂ in the oxidation of SO₂</td> <td></td> <td style="text-align: center;">✓</td> </tr> <tr> <td>V₂O₅ in the Contact process</td> <td style="text-align: center;">✓</td> <td></td> </tr> </tbody> </table> | | heterogeneous | homogeneous | Fe in the Haber process | ✓ | | Fe ²⁺ in the I ⁻ / S ₂ O ₈ ²⁻ reaction | | ✓ | NO ₂ in the oxidation of SO ₂ | | ✓ | V ₂ O ₅ in the Contact process | ✓ | | 2 |
| | heterogeneous | homogeneous | | | | | | | | | | | | | | | |
| Fe in the Haber process | ✓ | | | | | | | | | | | | | | | | |
| Fe ²⁺ in the I ⁻ / S ₂ O ₈ ²⁻ reaction | | ✓ | | | | | | | | | | | | | | | |
| NO ₂ in the oxidation of SO ₂ | | ✓ | | | | | | | | | | | | | | | |
| V ₂ O ₅ in the Contact process | ✓ | | | | | | | | | | | | | | | | |

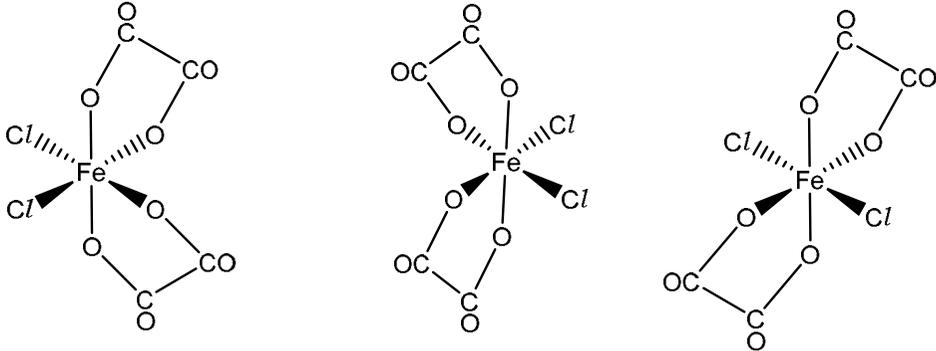
| Question | Answer | Marks |
|----------|--|----------|
| 5(a) | nitrile; alkene; chloro; benzene / arene | 2 |
| 5(b) |  | 1 |
| | addition (polymerisation) | 1 |

| Question | Answer | | | Marks |
|----------|--|--|-----------------------------------|----------|
| 5(c) | reagent | structure of product | type of organic reaction | 8 |
| | excess Br ₂ (aq) |  [1] | (electrophilic) addition | |
| | excess hot, conc. MnO ₄ ⁻ (aq) |  [1] + [1] | oxidation | |
| | excess hot, aqueous HCl |  [1] | hydrolysis | |
| | excess H ₂ /Pt catalyst |  both CH ₂ NH ₂ formed [1] both arene and alkene reduced [1] | reduction/ hydrogenation | |
| | | structures [6] | 2 correct for 1 mark total [2] | |

| Question | Answer | Marks |
|-----------|--|-------|
| 6(a)(i) |  | 1 |
| 6(a)(ii) | $\text{HNO}_3 + 2\text{H}_2\text{SO}_4 \rightarrow \text{H}_3\text{O}^+ + \text{NO}_2^+ + 2\text{HSO}_4^-$ | 1 |
| 6(a)(iii) | <p>any three from:</p> <p>Point 1: bonds/electrons are partially delocalised in T or delocalised/π system/π bonding extends over only five carbons</p> <p>Point 2: four π-electrons in the (delocalised system of T) or methylbenzene has (two) more π-electrons/(two) more delocalised electrons</p> <p>Point 3: contains a carbon that is sp^3 hybridised in T or (all the) carbons are sp^2 hybridised in methylbenzene</p> <p>Point 4: one carbon has a bond angle of 109.5°/tetrahedral (in T) or (C-C) bond strengths/lengths are not all the same or not all the bond angles are 120° (in T)</p> | 3 |
| 6(b)(i) | 4-aminobenzoic acid | 1 |
| 6(b)(ii) | <p>step 1 Sn + HCl [1] concentrated/reflux/heat [1] step 2 CH_3COCl [1] step 3 KMnO_4/manganate(VII)/MnO_4^- (acidified/alkaline) and heat [1] step 4 aqueous HCl and heat [1] step 5 ethanol, H_2SO_4, concentrated/reflux/heat [1]</p> | 6 |

| Question | Answer | Marks | | | | | | | | | | | | | | | | | | | | |
|--------------|---|--|--------------------------------|--|-------------------|-----|-------------------|---|---------|-----|---------------------|---|---------|-----|-----------------|---|-----------------|---------|-------------------------------------|---|------------------|----------|
| 6(c) | (benzocaine) is less (basic than ethylamine) AND lone pair (on N) is less available to accept a proton/H ⁺ since (lone pair on N) is delocalised over the ring or phenyl ring is electron withdrawing group OR ethylamine is more basic (than benzocaine) AND lone pair (on N) is more available to accept a proton/H ⁺ since ethyl/alkyl group is electron-donating group | 2 | | | | | | | | | | | | | | | | | | | | |
| 6(d)(i) | 7 peaks | 1 | | | | | | | | | | | | | | | | | | | | |
| 6(d)(ii) | CDCl ₃ will produce no signal in the spectrum or CHCl ₃ would produce a signal/would be detected | 1 | | | | | | | | | | | | | | | | | | | | |
| 6(d)(iii) | <table border="1"> <thead> <tr> <th>δ/ppm</th> <th>group responsible for the peak</th> <th>number of H atoms responsible for the peak</th> <th>splitting pattern</th> </tr> </thead> <tbody> <tr> <td>1.2</td> <td>CH₍₃₎</td> <td>3</td> <td>triplet</td> </tr> <tr> <td>3.5</td> <td>CH₍₂₎O</td> <td>2</td> <td>quartet</td> </tr> <tr> <td>5.5</td> <td>NH₂</td> <td>2</td> <td>singlet (broad)</td> </tr> <tr> <td>7.1–7.4</td> <td>H attached to aromatic/benzene ring</td> <td>4</td> <td><i>multiplet</i></td> </tr> </tbody> </table> | δ/ppm | group responsible for the peak | number of H atoms responsible for the peak | splitting pattern | 1.2 | CH ₍₃₎ | 3 | triplet | 3.5 | CH ₍₂₎ O | 2 | quartet | 5.5 | NH ₂ | 2 | singlet (broad) | 7.1–7.4 | H attached to aromatic/benzene ring | 4 | <i>multiplet</i> | 4 |
| δ/ppm | group responsible for the peak | number of H atoms responsible for the peak | splitting pattern | | | | | | | | | | | | | | | | | | | |
| 1.2 | CH ₍₃₎ | 3 | triplet | | | | | | | | | | | | | | | | | | | |
| 3.5 | CH ₍₂₎ O | 2 | quartet | | | | | | | | | | | | | | | | | | | |
| 5.5 | NH ₂ | 2 | singlet (broad) | | | | | | | | | | | | | | | | | | | |
| 7.1–7.4 | H attached to aromatic/benzene ring | 4 | <i>multiplet</i> | | | | | | | | | | | | | | | | | | | |
| 6(d)(iv) | neighbouring/adjacent carbon atom has two protons/H (attached to it) or there is an adjacent CH ₂ (O) group | 1 | | | | | | | | | | | | | | | | | | | | |
| 6(d)(v) | peak at 5.5/NH ₂ peak will disappear and NH ₂ /protons exchange/swap with deuterium | 1 | | | | | | | | | | | | | | | | | | | | |

| Question | Answer | Marks |
|----------|--|-------|
| 6(e)(i) | $\text{NaNO}_2 + \text{HCl}$ <i>or</i> HNO_2 | 1 |
| 6(e)(ii) | <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>R</p> </div> <div style="text-align: center;">  <p>S</p> </div> </div> | |
| | structure of diazonium salt R | 1 |
| | structure of azo dye S | 1 |

| Question | Answer | Marks |
|----------|--|-------|
| 7(a) | Fe atom = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^6 4s^2$ Fe ³⁺ ion = $(1s^2 2s^2 2p^6) 3s^2 3p^6 3d^5$ | 1 |
| 7(b) | $([H^+]^2 = 8.9 \times 10^{-4} \times 0.25 \text{ or } 2.225 \times 10^{-4})$ $[H^+] = 0.0149$ | 1 |
| | pH = $-\log(0.0149) = 1.83$ | 1 |
| 7(c)(i) | (K_{stab}) is the equilibrium constant for the formation of a complex (ion) (in a solvent from its constituent ions/molecules) | 1 |
| 7(c)(ii) | $[\text{Fe}(\text{H}_2\text{O})_5\text{F}]^{2+}$ and $[\text{Hg}(\text{H}_2\text{O})_5\text{Cl}]^+$ | 1 |
| 7(d) | $K_{\text{stab}} = \frac{[\text{Fe}(\text{ed})_2\text{Cl}_2^{3-}]}{[\text{Fe}(\text{H}_2\text{O})_4\text{Cl}_2^+][\text{ed}]^2}$ | 1 |
| | $\text{mol}^{-2} \text{dm}^6$ | 1 |
| 7(e)(i) |  <p style="text-align: center;">cis cis trans</p> | 3 |

| Question | Answer | Marks |
|-----------|---|----------|
| 7(e)(ii) | any cis isomer and the trans isomer identified | 1 |
| 7(e)(iii) | both correct cis isomers identified | 1 |
| 7(e)(iv) | trans isomer identified | 1 |