# **Student Book Unit 5** Test 1 Mark scheme (Chapters 2.1 to 2.2)

**1 a** (i) +2 to +2.5 (or 0.5) **(1)**
$I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$ **(1)** **(2)**
*allow* $S_4O_6^{2-} + 2I^- \rightleftharpoons I_2 + 2S_2O_3^{2-}$
*but not* $S_4O_6^{2-} + 2I^- \rightarrow I_2 + 2S_2O_3^{2-}$

(ii) +2 to +6 (or 4) **(1)**
$4XCl_2 + 2S_2O_3^{2-} + 5H_2O \rightarrow 8Cl^- + 2SO_4^{2-} + 10H$ species **(1)**; balanced **(1)** **(3)**
*allow* $8Cl^- + 2SO_4^{2-} + 10H^+ \rightleftharpoons 4Cl_2 + 2S_2O_3^{2-} + 5H_2O$
*but not* $8Cl^- + 2SO_4^{2-} + 10H^+ \rightarrow 4Cl_2 + 2S_2O_3^{2-} + 5H_2O$
*if the equations are given the wrong way round with an → but the oxidation number changes are given correctly for these equations as –0.5 and –4 then the 2 oxidation state marks can be given*

**b** The colour change is not sharp / not easy to see **(1)**; no suitable indicator **(1)** **(2)**
*or bromine is volatile / is lost from the system (1); therefore results are not accurate / reliable (1)*

**(Total 7 marks)**

**2 a** Potential / e.m.f. / voltage / half-cell of electrode **(1)**; relative to (standard) hydrogen electrode **(1)**; solutions of unit concentration **(1)**; and gases at 1 atm / standard temperature **(1)** **(max 2)**

**b** Voltmeter requires two connections / measure potential difference **(1)**; and so another electrode is introduced into system **(1)** **(2)**
*allow 'for redox has to have a source / sink of electrons' (1)*

**c** (i) Reaction in which a given species / substance / molecule / ion is *simultaneously / both* oxidised and reduced **(1)**
*not atom*

(ii) $E^{\ominus}_{cell}$ for disproportionation is +1.23V − (+1.70V) = −0.47V **(1)**
*or equivalent in words (1)*
(This is negative) so reaction does not occur **(1)** **(3)**
*second mark is consequential on the first statement*

**(Total 7 marks)**

**3 a** (i) $Cu + 4H^+ + 2NO_3^- \rightarrow Cu^{2+} + 2NO_2 + 2H_2O$; species **(1)**; balanced **(1)**
*or similar reaction with Zn or Ni*
*balancing mark conditional on correct species*

(ii) Redox **(1)** **(3)**

**b** (i) $[Cu(H_2O)_6]^{2+}$; $[Ni(H_2O)_6]^{2+}$; $[Zn(H_2O)_6]^{2+}$ or $[Zn(H_2O)_4]^{2+}$
3 correct **(2)**; 2 correct **(1)**; 1 correct **(0)**

(ii) $Cu(OH)_2$ **(1)**; $Ni(OH)_2$ **(1)**
*ignore any hydration*
*if $Zn(OH)_2$ is included then (−1)*

(iii) $[Zn(OH)_4]^{2-}$ or $[Zn(OH)_3]^-$ or $ZnO_2^{2-}$ **(1)** **(5)**
*ignore any hydration in the first two, but the last must not include any hydration*
*not $[Zn(OH)_6]^{4-}$*

# Student Book Unit 5 Test 1 Mark scheme (cont.)

**c** (i) e.g. $[Cu(H_2O)_6]^{2+} + 2OH^- \rightarrow Cu(OH)_2 + 6H_2O$; species **(1)**; balanced **(1)**
*balancing mark conditional on correct species*
*$H_2O$s on right-hand side must add up to 6*

(ii) deprotonation or acid–base **(1)** **(3)**
*not hydrolysis or precipitation*

**d** NaOH to remove nitric acid **(1)**; which would interfere with the redox reaction or would oxidise iodide ions or solution must be acidic to keep $Cu^{2+}$ ions in solution **(1)**
Quality of language **(1)** **(3)**

**e** (i) $2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2NaI$ **(1)**
*or $Na_2S_2O_3 + \frac{1}{2}I_2$ etc.*
*accept ionic equation*
Add starch when solution pale yellow **(1)**
*not towards the end point*
If added too soon gives ppt. or insoluble complex **(1)** **(3)**

(ii) No. of moles $S_2O_3^{2-} = \frac{0.1 \times 18.7}{1000}$ **(1)**
relate to moles $Cu^{2+}$ (equation or statement) **(1)**
no. of moles $Cu^{2+} = 1.87 \times 10^{-3}$ in 25 $cm^3$
So no. of moles $Cu^{2+} = 1.87 \times 10^{-3} \times 20$ in 500 $cm^3$ **(1)**
mass $Cu^{2+}$ = no. of moles in 500 $cm^3 \times 63.5$ g in 500 $cm^3 = 2.375$ g **(1)**
So, %Cu $= \frac{2.375 \times 100}{9.5} = 25.0\%$ (24.99) **(1)** **(5)**
*25.0% and some working scores (5)*
*if reaction stoichiometry is incorrect then (max 4)*

(iii) Comment on relative magnitude of $E^{\ominus}$ values **(1)**
So, $Cu^{2+}$ should not oxidise $I^-$ to $I_2$ (under standard conditions) **(1)**
relevance of insolubility of CuI **(1)** **(3)**

**(Total 25 marks)**

**4** Coloured ions / compounds **(1)** (*not metals*)
complex ions / form complexes **(1)**
paramagnetic ions / compounds **(1)**
variable valency or oxidation state **(1)**
catalytic activity **(1)**
high melting or boiling temperature / high density **(1)** **(max 3)**
*not part filled d-shells or just 'paramagnetism'*

**(Total 3 marks)**

# **Student Book Unit 5** Test 1 Mark scheme (cont.)

**5 a** (i) Deprotonation **(1)**

(ii) Ligand exchange / transfer / complex (ion) formation **(1)** **(2)**

**b** $Cu(OH)_2$ **(1)** **(1)**
*accept up to four water molecules in addition*

**c** $[Cu(NH_3)_4]^{2+}$ **(1)** planar drawn **(1)**; not tetrahedral **(2)**
or $[Cu(NH_3)_4(H_2O)_2]^{2+}$ (1) octahedral (1)
or $[Cu(NH_3)_6]^{2+}$ (1) octahedral (1)
*allow any of 1 to 6 $NH_3$ with 5 to 0 $H_2O$ to balance*

**(Total 5 marks)**

**6 a** Not all d orbitals full / incomplete d orbitals **(1)** **(1)**

**b** dative (covalent), co-ordinate **(1)** and covalent **(1)** **(2)**
*if ionic or metallic given with other types of bonding (– 1)*

**(Total 3 marks)**