1. (a) *Hydrogen ion concentration*: 1.00 mol dm^{-3} **(1)**

Hydrogen gas pressure: 100 kPa **(1)** 2

(b) *Explanation of change*: Equilibrium displaced to left **(1)**
to reduce constraint **(1)**

Change in electrode potential: Becomes negative or decreases **(1)** 3
allow more negative

(c) (i) 0.43V **(1)**

(ii) *Half-equation*: $2Br^- \rightarrow Br_2 + 2e^-$ **(1)**

Overall equation: $2BrO_3^- + 10Br^- + 12H^+ \rightarrow 6Br_2 + 6H_2O$ **(2)** 4
or $BeO_3^- + 5Br^- + 6H^+ \rightarrow 3Br_2 + 3H_2O$
*species **(1)***
*balanced **(1)***

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2. (a) Platinum electrode **(1)**
Hydrogen gas **(1)**
$H^+(aq)$ or HCl or H_2SO_4 **(1)**

298 k **(1)**
100 kPa or 1 atm or 1 bar **(1)**
1 M $[H^+]$ **(1)** 6

(b) (i) 1.61 V **(1)**

(ii) Positive **(1)** 2

(c) (i) 1.36 V **(1)**
Left to right **(1)**

Allow on diagram 2

(d) $Ce^{4+} + e^- \rightarrow Ce^{3+}$ **(1)**
$V^{3+} + H_2O \rightarrow VO^{2+} + 2H^+ + e^-$

or reversed

or $V^{3+} + 2H_2O \rightarrow VO_2^+ + 4H^+ + 2e^-$ **(1)**

or reversed

$Ce^{4+} + V^{3+} + H_2O \rightarrow VO^{2+} + 2H^+ + Ce^{3+}$

or $2Ce^{4+} + V^{3+} + 2H_2O \rightarrow VO_2^+ + 4H^+ + 2Ce^{3+}$ **(1)** 3

(e) VO^{2+} **(1)** VO_2^+ **(1)** 2

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3. (a) most powerful reducing agent: Zn; 1

(b) (i) reducing species: Fe^{2+} 1

(ii) oxidising species: Cl_2; 1

(c) (i) standard electrode potential 1.25 V; 1

(ii) equation: $Tl^{3+} + 2\ Fe^{2+} \rightarrow 2Fe^{3+} + T1+$ balanced; correct direction; 1 1

[6]

4. (a) (i) *Primary standard* = standard hydrogen electrode **(1)**

Secondary standard = simpler OR easily constructed OR more reliable
OR safer OR, less danger **(1)**

(ii) *Equations*

$H+(aq) + e^- \rightarrow ½\ H_2\ (g)$ **(1)** $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ **(1)** **(2)**

overall: $2H^+ + Fe \rightarrow Fe^{2+} + H_2$ **(1)**

Conditions

SHE: H^+ 1 M **(1)** 1 bar **(1)** Pt electrode **(1)** T =298K **(1)**

Fe pure **(1)** Fe^{2+} 1 M **(1)** salt bridge **(1)** zero current **(1)**

$E^{\ominus}$ = 0 V definition OR e.m.f. = $E^{\ominus}$ (Fe^{2+}/Fe) **(1)**

Precautions

H_2 explosive in air OR Fe^{2+} oxidised by air **(1)** 12

(b)

			$E^{\ominus}$/V
$2Fe^{3+}(aq)$	+ $6e^-$	$\rightarrow 2Fe(s)$	–0.04
$3Fe^{2+}(aq)$	+ $6e^-$	$\rightarrow 3Fe(s)$	–0.44
$2Fe^{3+}(aq)$	+ Fe(s)	$\rightarrow 3Fe^{2+}(aq)$	+0.40

correct direction **(1)** balance **(1)** standard states **(1)** $E^{\ominus}$ value (>0) **(1)** 4

			$E^{\ominus}$/V
$3Au^+(aq)$	+ $3e^-$	$\rightarrow$ 3 Au(s)	+ 1.69
$Au^{3+}(aq)$	+ $3e^-$	$\rightarrow$ Au (s)	+ 1.40
	$3Au^+(aq)$	$\rightarrow Au3^+(aq)$ + 2Au(s)	+0.29

correct direction **(1)** balance **(1)** standard states **(1)** $E^{\ominus}$ value (>0) **(1)** 4

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