Name of the Student:_____
Max. Marks : 21 Marks **Time : 21 Minutes**

Mark Schemes

Q1.

(a) (List of) electrode potentials/ $E^{\ominus}$ in (numerical) order

OR half cells/equations in (numerical) order of electrode potential/ $E^{\ominus}$

Do not allow EMF in order

1

(b) Any 2 from
298 K **or** 25 ^{o}C
$[H^+] = 1$ mol dm^{-3}
100 kPa

Ignore 1 atm

1

(c) $[Co(H_2O)_6]^{2+}$

Do not penalise absence of brackets

1

(d) $3\ VO_2^+ + 6\ H^+ + Fe + 3\ H_2O \rightarrow 3\ VO^{2+} + [Fe(H_2O)_6]^{3+}$

or

$3\ VO_2^+ + 6\ H^+ + Fe \rightarrow 3\ VO^{2+} + 3\ H_2O + Fe^{3+}$

1 mark for Fe^{3+} as product and one mark for equation.

Ignore state symbols
Allow 1 mark for balanced equation that gives Fe^{2+} as product
$2VO_2^+ + 4H^+ + Fe + 4H_2O \rightarrow 2VO^{2+} + [Fe(H_2O)_6]^{2+}$
or
$2VO_2^+ + 4H^+ + Fe \rightarrow 2VO^{2+} + Fe^{2+} + 2H_2O$

2

(e) $E^{\ominus}$ $Co^{3+}(/Co^{2+}) > Fe^{3+}(/Fe^{2+})$

*Allow electrode potential for Co^{3+} greater than for Fe^{3+} **OR** 1.81 > 0.77 / EMF cell = 1.04 V*

1

$[Co(H_2O)_6]^{3+} + [Fe(H_2O)_6]^{2+} \rightarrow [Co(H_2O)_6]^{2+} + [Fe(H_2O)_6]^{3+}$

Insist of reference to $E^{\ominus}$ in M1

1

(f) Different ligands

Penalise different concentrations/oxidation states

1

[8]

Q2.

(a) $H_2(g)$ **AND** 100kPa

Allow 1 bar

NOT 1 atm or 101kPa

0.5 mol dm^{-3} and H_2SO_4

1

1 mol dm^{-3} **AND** $HCl/HNO_3/H^+$

1

Pt electrode **AND** temperature of 298 K (25^oC)

1

(b)

This question is marked using levels of response. Refer to the Mark Scheme Instructions for examiners for guidance on how to mark this question	
Level 3 **5-6 marks**	All stages are covered and the explanation of each stage is correct and virtually complete Answer communicates the whole explanation, coherently and shows a logical progression through all three stages. 'Coherence' requires clear practical details (e.g. weighing into beaker/ by difference/ plus washings, not straight into volumetric flask, saturated solution chosen for salt bridge, salt bridge solution is suitable)
Level 2 **3-4 marks**	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages covered and the explanations are generally correct and virtually complete Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete
Level 1 **1-2 marks**	Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** only one stage is covered but the explanation is generally correct and virtually complete Answer shows some progression between two stages
Level 0 **0 marks**	Insufficient correct Chemistry to warrant a mark

Indicative Chemistry content

Stage 1: Preparing solution

(1a) Weigh 7.995 / 8.00 g $TiOSO_4$

(1b) Dissolve in / add (allow react with) (0.50 mol dm^{-3}) sulfuric acid

(1c) transfer to volumetric flask and make up to the mark

Stage 2: Set up cell
Content can be shown in a labelled diagram
(2a) piece of Ti immersed in (1 mol dm^{-3} acidified) $TiO^{2+}(aq)$ / the solution

(2b) (connect solutions with) salt bridge or description

(2c) (connect metals through high R) voltmeter

Stage 3: Measurements and calculation

(3a) record voltage/potential difference/emf of the cell

(3b) $E_{cell} = E_{RHS} - E_{LHS}$
$E_{cell} = E_{copper} - E_{titanium}$

(3c) $E_{LHS} = E_{RHS} - E_{cell}$ OR E_{cell} should be +1.22 V if Cu on RHS (or −1.22 if Cu electrode on LHS)

6

(c) $TiO^{2+} + 2H^+ + 4e^{(-)} \rightarrow Ti + H_2O$

Allow reverse reaction
Ignore state symbols
Allow multiples or fractions
Allow equilibrium arrow

1

(d) ((+)0.34 compared with 0.00 shows that)
E_{cell} for $Cu + 2H^+ \rightarrow H_2 + Cu^{2+}$ / reaction of copper with most acids is negative / −0.34 / (+)0.34 shows Cu less powerful reducing agent than H_2

***OR** M1 **(**E^o**)** H^+/H_2 (or the hydrogen <u>electrode</u>) less +ve/< than **(**E^o**)** Cu^{2+}/Cu (or the copper <u>electrode</u>) so H^+ cannot oxidise Cu to Cu^{2+} / H^+ poorer oxidising agent (or reverse argument)*

1

((+)0.96 compared with (+)0.34 shows that)
E_{cell} for reaction of Cu with nitrate/nitric acid is positive / (+)0.62 V

*M2 **(**E^o**)** NO_3^-/NO (or the nitrate/nitric acid <u>electrode</u>) more +ve/> than **(**E^o**)** Cu^{2+}/Cu (or the copper <u>electrode</u>) so NO_3^- can oxidise Cu to Cu^{2+} (or reverse argument)*

1

$2NO_3^- + 8H^+ + 3Cu \rightarrow 2NO + 4H_2O + 3Cu^{2+}$

Allow multiples or fractions
Ignore state symbols

1

[13]