Equilibria, Energetics and Elements
Electrode Potentials and Fuel Cells

59 marks

1. (i) oxidation: $Fe \rightarrow Fe^{2+} + 2e^-$ **(1)**
reduction: $V^{3+} + e^- \rightarrow V^{2+}$ **(1)** 2

(ii) $E_{cell} = 0.18$ V **(1)** 1

[3]

2. (i) system **III** × 2 and reversed + system **IV** **(1)**
$2H_2 + O_2 \rightarrow 2H_2O$/
$H_2 + ½O_2 \rightarrow H_2O$ **(1)** 2

(ii) advantages:
only H_2O formed/ non-polluting
greater efficiency **(1)**

disadvantages:
H_2 difficult to store **(1)**
H_2 difficult to manufactured initially /
limited life cycle of H_2 adsorber/absorber **(1)** 4

[6]

3. (a) Emf/voltage/potential difference (of electrochemical cell) 1
comprising a (Cu/Cu^{2+}) half cell combined with a standard
hydrogen electrode 1
1 atm, 1 mol.dm^{-3}, 298K (all 3 needed but can transfer mark if stated in (b)) 1

(b) Salt bridge and voltmeter 1
Platinum electrode dipping into 1 mol dm^{-3} H^+ 1
Hydrogen gas feed 1
(Accept a suitable alternative standard electrode)

[6]

4. (a) (i) Stainless steel + corrosion resistance or alloys for tools
+ hardness or other named alloy/use/property 1
Allow chrome plating with attractive or barrier to corrosion

(ii) Chromium $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ (allow….$4s^1 3d^5$) 1

(b) (i) $Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ 1

$Cr_2O_7^{2-}$ / Cr^{3+} has more positive electrode potential 1

Therefore $Cr_2O_7^{2-}$ is the stronger oxidising agent which oxidises Fe^{2+} to Fe^{3+} (ora) 1

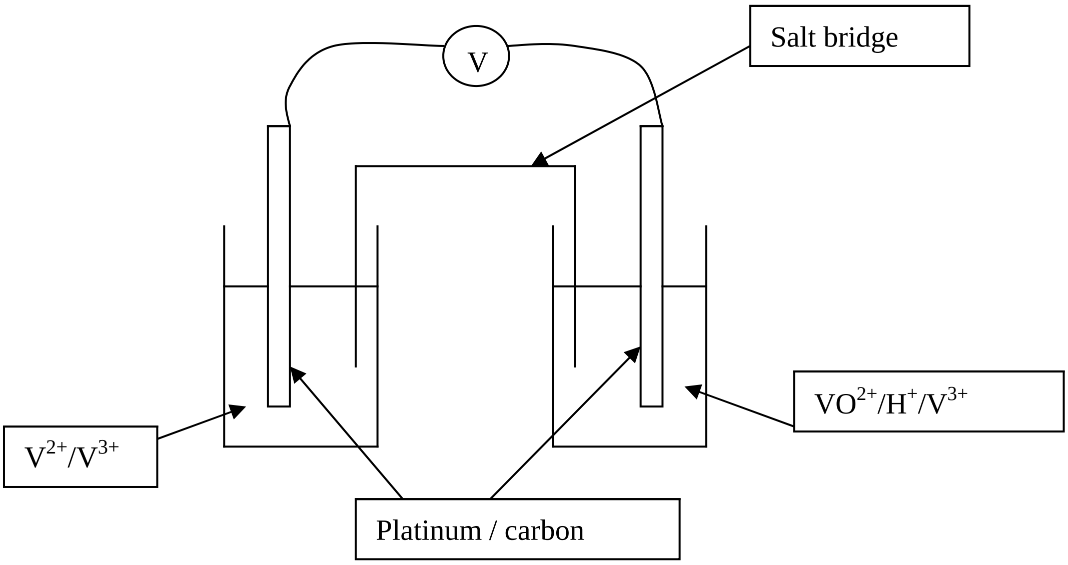
(ii) Emf = (+) 0.56 V 1

[6]

5. (a) VO_2^+ 1

(b) (i) B and D 1

(ii)



Allow ecf from (b) (i)

Solutions can be reversed. 4

(iii) 298 K / 25 °C temperature

all solutions 1 mol dm^{-3}

Both needed for 1 mark. Ignore any reference to pressure 1

[7]

6. (a) A = Platinum(electrode)

B = H^+(aq) / HC*l*(aq) / other suitable acid

C = Voltmeter / galvanometer

D = Cl_2(g)

State symbols needed for B and D

All correct = 2, 3 correct = 1 2

(b) (i) Arrow marked on or close to wire via voltmeter pointing from hydrogen half cell to chlorine half cell 1

Electrons flow to half cell with more +ve standard electrode potential 1

(ii) Pressure = 1 Atm / 100 kPa

Temp = 298 K / 25°C

Concentration = 1 mol dm^{-3}

All 3 correct = 2 marks 2 correct = 1 mark 2

(c) The standard electrode potential for ClO_3^- / ½Cl_2 is more positive than that of ½ Cl_2 / Cl^- 1

ClO_3^- has a greater tendency to gain electrons than Cl_2 / ClO_3^- is a better oxidising agent than Cl_2 1

Alternative:

Because $E^{\ominus}$ is positive, the reaction will go from left to right therefore ClO_3^- is reduced so it must be a better oxidising agent than chlorine.

[8]

7. (a) Emf / voltage / potential difference 1

Half cell combined with standard hydrogen electrode 1

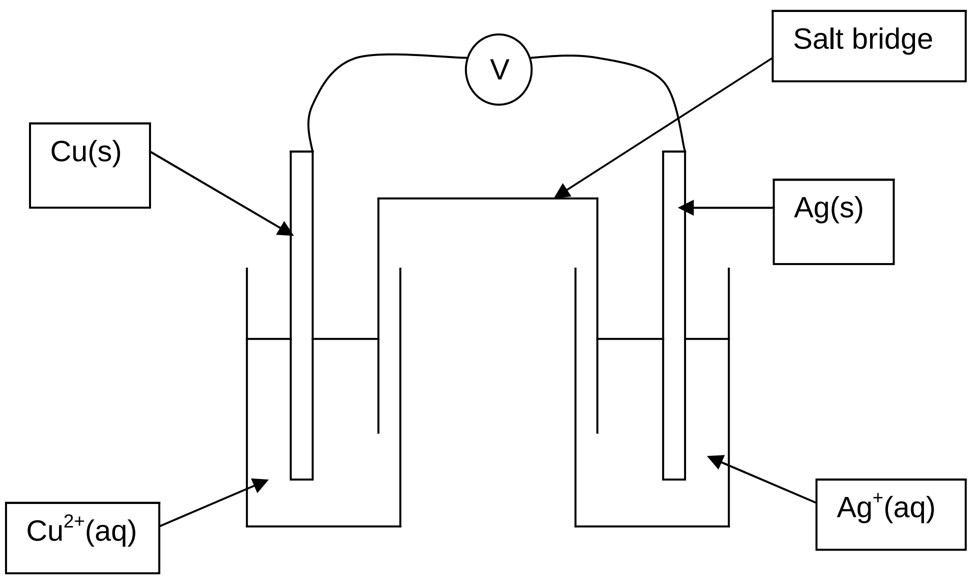
Standard conditions 298K, 1 mol dm^{-3}, 1 atm 1

(all 3 required for 1 mark)

(b) (i) Diagram shows:

Voltmeter + salt bridge + complete circuit 1

Solution labelled Cu^{2+} and electrode labelled Ag 1



(ii) Direction from Cu(s) to Ag(s) (must be in / close to wire) 1

(iii) $0.80 - 0.34 = 0.46$ V 1

(iv) $Cu + 2Ag^{+} \rightarrow Cu^{2+} + 2Ag$ 1

(c) Standard Electrode Potential for chlorine is more positive than Fe^{3+} therefore it is a better oxidising agent than Fe^{3+} (do not accept $E^{\ominus}$ is larger or smaller) 1

Standard Electrode Potential for iodine is less positive than Fe^{3+} therefore it is a poorer oxidising agent than Fe^{3+} 1

(Accept release of electrons/equilibrium arguments)

[10]

8. $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$ **(1)**

N from +4 to +5
O from 0 to –2 **(1)** Could be below equation 2

[2]

9. (a) Emf of a cell / voltage / potential difference / cell potential 1
Comprising half cell combined with standard hydrogen electrode 1
Conc = 1 $mol.dm^{-3}$; Pressure (of H_2) = 1 atm; Temp = 298K 1
(all of above = 1 mark)

(b) +0.16 V (unit required) 1

[4]

10. (a) (i) $2MnO_4^{-} + 10Cl^{-} + 16H^{+} \rightarrow 2Mn^{2+} + 5Cl_2 + 8H_2O$ 1

correct species on both sides of equation equation balanced 1
(ignore electrons for first mark, penalise for balance)

(ii) Chlorine $-1 \rightarrow 0$ 1
Manganese $+7 \rightarrow +2$ 1
Link to (i) and allow ecf

(iii) Chloride ion oxidised (not chlorine) 1
Manganate(VII) ion reduced (not manganese) 1

(b) 0.16 V too small/rate too slow/insufficient activation energy/not standard conditions 1

[7]