F325: Equilibria, Energetics and Elements

5.2.3 Electrode Potentials and Fuel Cells

59 marks

1. (i) oxidation: Fe → Fe^{2+} + 2e^- (1)
   reduction: V^{3+} + e^- → V^{2+} (1)

(ii) \( E_{\text{cell}} = 0.18 \text{ V} \) (1)

2. (i) system III \times 2 and reversed + system IV (1)
   \( 2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O} / \text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O} \) (1)

(ii) advantages:
   only \( \text{H}_2\text{O} \) formed/ non-polluting
   greater efficiency (1)

   disadvantages:
   \( \text{H}_2 \) difficult to store (1)
   \( \text{H}_2 \) difficult to manufactured initially /
   limited life cycle of \( \text{H}_2 \) adsorber/absorber (1)

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

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

4. (a) (i) Stainless steel + corrosion resistance or alloys for tools
   + hardness or other named alloy/use/property
   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\(^5\))
5. (a) \( \text{VO}_2^+ \)  
(b) (i) B and D  
   (ii) \( \text{Emf} = (+) 0.56 \text{ V} \)  
   (iii) 298 K / 25 °C temperature  
       all solutions 1 mol dm\(^{-3}\)  
       Both needed for 1 mark. Ignore any reference to pressure  

6. (a) A = Platinum(electrode)  
       B = \( \text{H}^+(aq) / \text{HCl}(aq) / \) other suitable acid  
       C = Voltmeter / galvanometer  
       D = \( \text{Cl}_2(g) \)  
       State symbols needed for B and D  
       All correct = 2, 3 correct = 1
(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 1
Temp = 298 K / 25°C 1
Concentration = 1 mol dm–3 1
All 3 correct = 2 marks 2 correct = 1 mark

(c) The standard electrode potential for ClO₃⁻ / ½Cl₂ is more positive than that of ½ Cl₂ / Cl⁻ 1
ClO₃⁻ has a greater tendency to gain electrons than Cl₂ / ClO₃⁻ is a better oxidising agent than Cl₂ 1
Alternative:
Because E° is positive, the reaction will go from left to right therefore ClO₃⁻ is reduced so it must be a better oxidising agent than chlorine.

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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 Cu²⁺ and electrode labelled Ag 1

(ii) Direction from Cu(s) to Ag(s) (must be in / close to wire) 1
(iii) \(0.80 - 0.34 = 0.46 \text{ V}\)

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

(c) Standard Electrode Potential for chlorine is more positive than \(\text{Fe}^{3+}\) therefore it is a better oxidising agent than \(\text{Fe}^{3+}\) (do not accept \(E^0\) is larger or smaller)

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

(Accept release of electrons/equilibrium arguments)

8. \(4\text{NO}_2 + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{HNO}_3\) (1)

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

9. (a) Emf of a cell / voltage / potential difference / cell potential
Comprising half cell combined with standard hydrogen electrode
Conc = 1 mol.dm\(^{-3}\); Pressure (of \(\text{H}_2\)) = 1 atm; Temp = 298K
(all of above = 1 mark)

(b) +0.16 V (unit required)

10. (a) (i) \(2\text{MnO}_4^- + 10\text{Cl}^- + 16\text{H}^+ \rightarrow 2\text{Mn}^{2+} + 5\text{Cl}_2 + 8\text{H}_2\text{O}\)

Correct species on both sides of equation equation balanced

(ignore electrons for first mark, penalise for balance)

(ii) Chlorine –1 → 0
Manganese +7 → +2
Link to (i) and allow ecf

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

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