

Electrolysis, Electrode Potentials & Cells

Mark Scheme 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Electrochemistry
Sub-Topic	Electrolysis, Electrode Potentials & Cells
Paper Type	Theory
Booklet	Mark Scheme 2

Time Allowed: 80 minutes

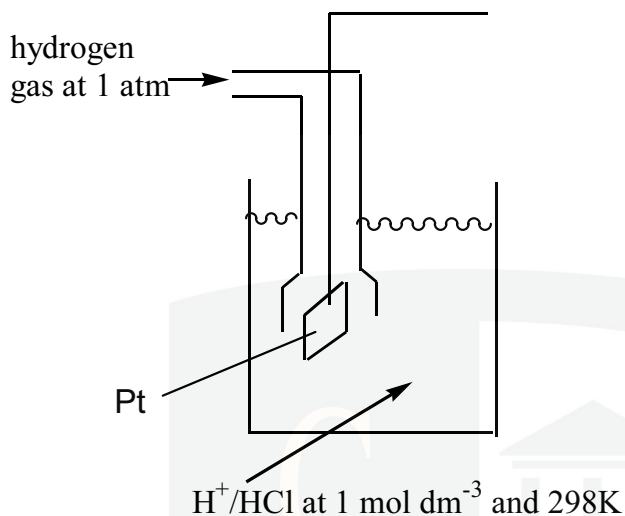
Score: /66

Percentage: /100

Grade Boundaries:

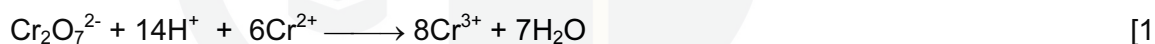
A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 (a)



$\text{H}_2(\text{g})$ going in (i.e. not being produced) [1]
 platinum electrode in contact with solution, with H_2 bubbling over it [1]
 H^+ or HCl or H_2SO_4 [1]
 solution at 1 mol dm^{-3} (or 0.5 M if H_2SO_4) and $T=298 \text{ K}$, $p=1 \text{ atm}$ [1]

(ii) $E^\ominus = 1.33 - (-0.41) = 1.74 \text{ V}$ [1]



(iii) Colour would change from orange [1]

to green [1]

[8]

(b) there are two ways of calculating the ratio:

$$\text{p}K_a = -\log_{10}(K_a) = -\log_{10}(1.79 \times 10^{-5}) = 4.747 \text{ (4.75) or } [\text{H}^+] = 10^{-5.5} = 3.16 \times 10^{-6} \quad [1]$$

$$\log_{10}([\text{B}] / [\text{A}]) = \text{pH} - \text{p}K_a = 0.753 \text{ (0.75) or } [\text{salt}] / [\text{acid}] = K_a / [\text{H}^+] \quad [1]$$

$$\therefore [\text{B}] / [\text{A}] = 10^{0.753} = 5.66$$

$$\text{or } = 1.79 \times 10^{-5} / 3.16 \times 10^{-6} = 5.66$$

$$\text{(or } [\text{A}] / [\text{B}] = \underline{0.177})$$

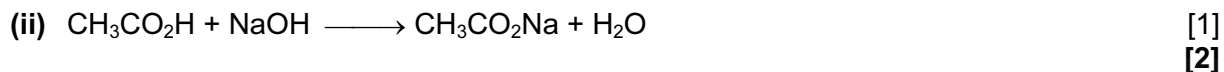
(correct ratio = [3] marks) [1]

$$\text{since } B + A = 100, \therefore (100-A) / A = 5.66 \Rightarrow$$

$$\frac{\text{vol of acid} = 15 \text{ cm}^3}{\text{vol of salt} = 85 \text{ cm}^3}$$

[1]

[4]



(d) e.g. hydrolysis of esters $\text{RCO}_2\text{R}' (+ \text{H}_2\text{O}) \longrightarrow \text{RCO}_2\text{H} + \text{R}'\text{OH}$ or its reverse

or hydrolysis of amides: $\text{RCONH}_2 (+ \text{H}_3\text{O}^+) \longrightarrow \text{RCO}_2\text{H} + \text{NH}_4^+$

hydrolysis of nitriles: $\text{RCN} (+ \text{H}_3\text{O}^+ + \text{H}_2\text{O}) \longrightarrow \text{RCO}_2\text{H} + \text{NH}_4^+$

nitration of benzene (or any arene): $\text{C}_6\text{H}_6 + \text{HNO}_3 \longrightarrow \text{C}_6\text{H}_5\text{NO}_2 (+ \text{H}_2\text{O})$

dehydration of alcohols, e.g. : $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3 \longrightarrow \text{CH}_3\text{CH}=\text{CH}_2 + \text{H}_2\text{O}$
(or the reverse)

halogenation of ketones, e.g. : $\text{CH}_3\text{COCH}_3 + \text{X}_2 \longrightarrow \text{CH}_3\text{COCH}_2\text{X} (+ \text{HX})$

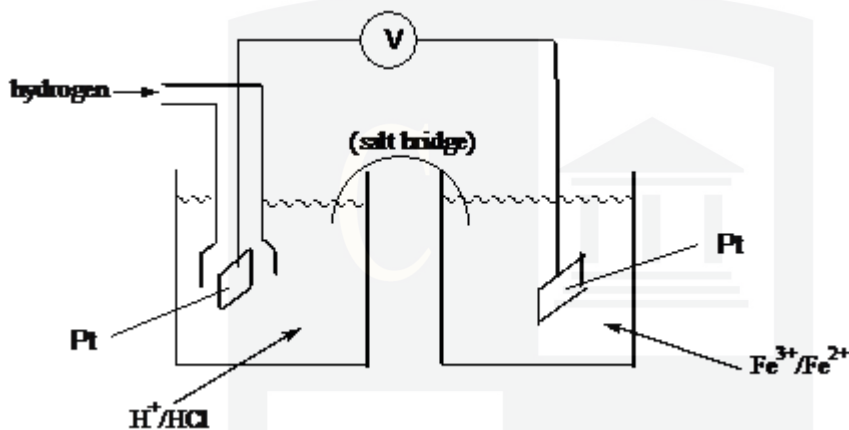
[3]

[Total: 17]

CHEMISTRY ONLINE
— TUITION —

- 2 (a) The potential of an **electrode** compared to that of a standard hydrogen electrode (SHE) or the EMF of a **cell** composed of the test electrode and the SHE [1]
- all measurement concentrations of 1 mol dm⁻³ and 298 K / 1 atm pressure [1]
- [2]

(b)



- H₂ and good delivery system [1]
 Fe²⁺/Fe³⁺ solution labelled [1]
 platinum electrodes (both) [1]
 salt bridge and voltmeter [1]
 H⁺ or HCl or H₂SO₄ [1]
 (acid is not sufficient) [5]

(c) (i) $E^\ominus = 0.77 - 0.54 = 0.23$ (V) [1]

(ii) Since E^\ominus is positive / $E^\ominus > 0$

So more products / the equilibrium will be over to the right / forward reaction is favoured
 ecf from (c)(i) [1]

(iii) $K_c = \frac{[\text{Fe}^{2+}]^2[\text{I}_2]}{[\text{Fe}^{3+}]^2[\text{I}^-]^2}$ [1]

units are mol⁻¹ dm³ ecf on expression [1]

(iv) ([Fe²⁺] must always be twice [I₂], so) [Fe²⁺] = 0.02 (mol dm⁻³) [1]

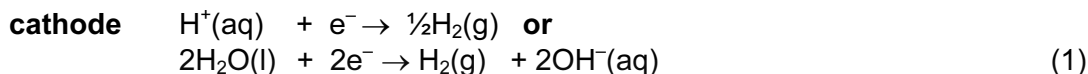
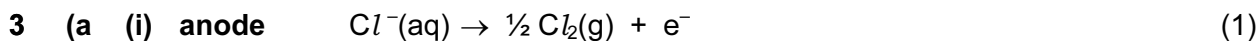
([I⁻] must always be equal to [Fe³⁺], so) [I⁻] = 2 × 10⁻⁴ (mol dm⁻³) [1]

(v) $K_c = \frac{\{(0.02)^2 \times 0.01\}}{\{(2 \times 10^{-4})^2 \times (2 \times 10^{-4})^2\}}$ correct expression [1]
 (allow ecf from incorrect expression in (c)(iii))

(allow ecf from (c)(iv))
 $= \frac{(4 \times 10^{-6})}{(1.6 \times 10^{-1.5})} = 2.5 \times 10^9$ (mol⁻¹ dm³) [1]

[8]

[Total: 15]



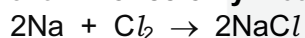
(ii) because iron in steel will react with chlorine (1) [3]

(b) **sod**

burns with a yellow **or** orange flame **or**

forms a white solid

allow – **once only** – colour of chlorine disappears (1)



phosphorus

burns with a white **or** yellow flame **or**

colour of chlorine disappears – if **not** given for Na – **or**

for PCl_5 forms a white **or** pale yellow solid

for PCl_3 forms a colourless liquid (1)



or



equation must refer to compound described (1) [4]

CHEMISTRY ONLINE
— TUITION —

(c) cold dilute aqueous NaOH

NaOCl (1)
+ (1)

hot concentrated aqueous NaOH

NaClO₃ (1)
+ (1)

(d) MgCl₂ 6.5 to 6.9 (1)

SiCl₄ 0 to 3 (1)

MgCl₂ dissolves without reaction **or**
slight **or** partial hydrolysis occurs (1)

SiCl₄ reacts with water **or**
hydrolysis occurs (1)

SiCl₄ + 2H₂O → SiO₂ + 4HCl **or**
SiCl₄ + 4H₂O → Si(OH)₄ + 4HCl **or**
SiCl₄ + 4H₂O → SiO₂·2H₂O + 4HCl (1) [5]

[Total: 16]

CHEMISTRY ONLINE
— TUITION —

- 4 (a) (i) **A = CuSO₄** [1]
B = silver [1]
- (ii) salt bridge [1]
voltmeter [1]
- [4]
- (b) (i) $0.80 - 0.34 = (+) 0.46 \text{ V}$ [1]
- (ii) If $E_{\text{cell}} = 0.17$, this is 0.29 V less than the standard E^\ominus ,
so $E_{\text{Ag electrode}}$ must = $0.80 - 0.29 = 0.51 \text{ V}$ [1]
- (iii) $0.51 = 0.80 + 0.06 \log [\text{Ag}^+]$, so $[\text{Ag}^+] = 10^{(-0.29/0.06)} = \underline{1.47 \times 10^{-5}} \text{ mol dm}^{-3}$ ecf from (ii) [1]
- [3]
- (c) $K_{\text{sp}} = [\text{Ag}^+]^2[\text{SO}_4^{2-}]$ [1]
units = $\text{mol}^3 \text{ dm}^{-9}$ ecf on K_{sp} [1]
- (ii) $[\text{SO}_4^{2-}] = [\text{Ag}^+]/2$ $K_{\text{sp}} = (1.6 \times 10^{-2})^2 \times 0.8 \times 10^{-2} = \underline{2.05 \times 10^{-6}} (\text{mol}^3 \text{ dm}^{-9})$ [1]
- [3]
- (d) AgCl white [1]
AgBr cream [1]
AgI yellow [1]
- Solubility decreases down the group [1]
- [4]
- (e) solubility decreases down the group [1]
as M^{2+} /ionic radius increases [1]
both lattice energy and hydration(solvation) energy to decrease [1]
enthalpy change of solution becomes more endothermic [1]
- [4]

[Total: 18]