ELECTROCHEMISTRY MARKING SCHEME
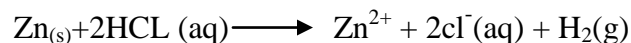
1. **1989 Q2 P1**

   Hydrogen and Oxygen

2. **1989 Q20 P1**

   Calcium is oxidized because it loses electrons / oxidation state of calcium increases / calcium gains oxygen. Water is reduced because Hydrogen oxidation state increases / water looses oxygen
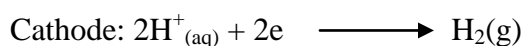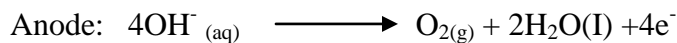
3. **1990 Q20 P1**

   $Zn_{(s)} + 2HCL\ (aq) \longrightarrow Zn^{2+} + 2cl^-(aq) + H_2(g)$

4. **1990 Q17 P1**

   Quality of electricity $= 3 \times 50 \times 60$ Columbus

   Mass of Cu deposited $= \dfrac{3 \times 50 \times 60 \times 63.5}{2 \times 96500}$

   $= 2.96$

5. **1991 Q9 P1**

   Anode: $4OH^-_{\ (aq)} \longrightarrow O_{2(g)} + 2H_2O(I) + 4e^-$

   Cathode: $2H^+_{\ (aq)} + 2e \longrightarrow H_2(g)$

6. **1992 Q16 P1**

   (a) Ca

   (b) (i) $Mg(s) + 2Ag^+\ (aq) \longrightarrow Mg^{2+}\ (aq) + Ag\ (s)$
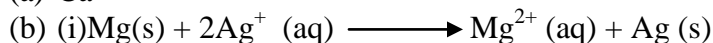
   (ii) $2.38 + 0.8 = 3.18$ volts, or $0.8 - (2.38) = 3.18$ volts

7. **1993 Q17 P1**

   $4OH\text{-}_{\ (aq)} \longrightarrow 2H_2O(I) + O_2 + 4e\text{ -}$

8. **1994 Q3 P1**

   Mass of water $34.8 - 15.9 = 18.9g$

   $\dfrac{18.9}{15.9} = \dfrac{18x}{106}$ $x = \dfrac{18.9 \times 106}{18 \times 15.5}$ $= \dfrac{2003.4}{286.2}$

9. **1995 Q9 P1**

When circuit is completed bulb lights (½) brown substance (½) formed grey (½)substance formed on cathode; because PbBr2 acts as an electrolyte (½) /free /mobile (½) ions; lead ions gain electrons to form pb(½) (Lead) and loses electrons to form (½) Bromine (Br) (Equations show ions current flow) (3 marks)

10. **1995 Q23 P1**

The chloride form ions in water which conduct electric current. NO ions are formed in methylbenzene /chloride exists in methylbenzene as molecules. (2 marks)

11. **1996 Q3 P2**

a) (i) Bauxite (1 mark)
(ii) Iron (III) Oxide/ silicon (IV) / silicon dioxide/ silica (1 mark)

b) (i)
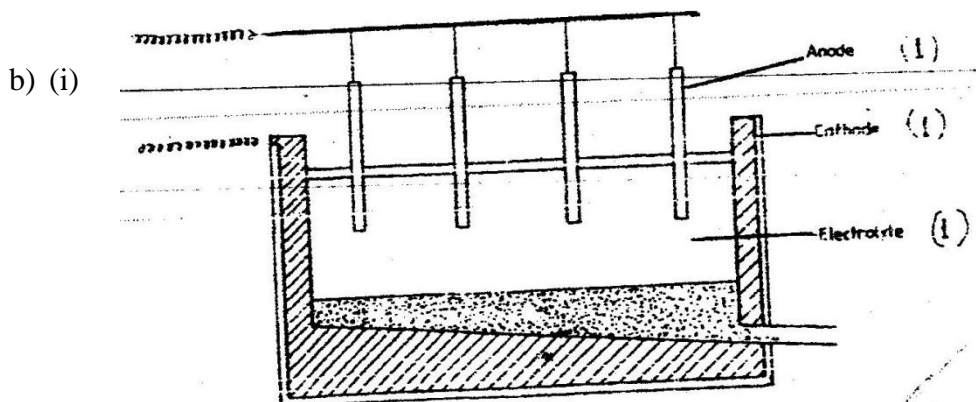
(ii) I. It is uneconomical/ expensive, because a lot of energy is required to produce this high temperature.
II. Addition of cryolite
(iii) The melting point is below 8000C.

c) Quantity of electricity = 40,000 x 60 x60 coulombs.
3x96, 500 coulombs of produce 27g of Al
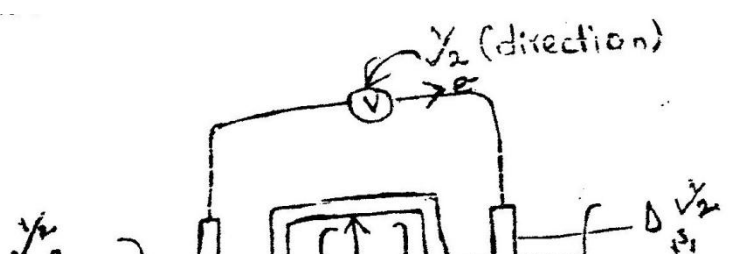40,000x 60 x 60 x27
3x 96,500x 1,000
= 13.4kg.

12. **1997 Q24 P1**

a) Cathode - Hydrogen
Anode - Oxygen
b) - It increases
c) - There would be an explosion potassium is very reactive.
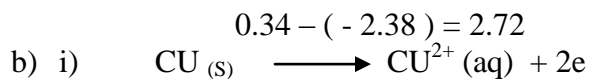- It would react with the solvent.

13. **1997 Q1 P2**

i) C^+ / C_2 Hydrogen is used as the reference electrode/ E^θ value is 0.000 / standard electrode potential.
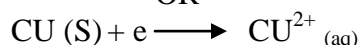ii) -2.90
iii)

iv) $2.38 + 0.34 = 2.72$
        OR
                $0.34 - (- 2.38) = 2.72$
b) i) $CU_{(S)} \longrightarrow CU^{2+}{}_{(aq)} + 2e$
                OR
            $CU_{(S)} + e \longrightarrow CU^{2+}{}_{(aq)}$

ii) $0.2 \times 5 \times 60 \times 60$ ½ $\dfrac{0.2 \times 5 \times 60 \times 60 \times 63.5}{2 \times 96500}$ $= 3600$ coulombs.

        63.5g Cu requires 2×96500
        3600 C produce $\dfrac{63.5 \times 3600}{2 \times 96500} = 1.18$gm

14.   1997 Q4 P1

a) (i)   - To lower M.P of NaCl from 800-600^{0}C hence reducing the cost of
            production of Na.
   (ii)   - Steel would react chlorine while graphite will not.
   (iii) - M.P lower than that of the electrolyte
          - Less dense than that of the eleactrolyte
   (iv) - To prevent the chlorine and sodium from mixing / coming into conduct/
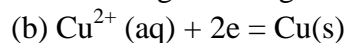   prevent products from mixing.
   (v)   I   Cathode $Na^+ (i) + e^- \longrightarrow Na_{(l)}$
       II   Anode $2Cl^-{}_{(l)} \longrightarrow Cl_{2(g)} + 2e^-$
   (i)   Manufacture of Na_2O_2, NaCN / alloy of Na + Pb to make T.E.L / Liquid Na –
             coolant in nuclear reactors / Na vapour used in extraction of titanium.

15.   1998 Q13 P1

(a) Because concentration of Cu^{2+} is high at the beginning and decreases as the ions are
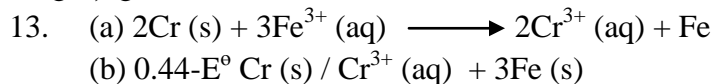   discharged during electrolysis
(b) $Cu^{2+}_{(aq)} + 2e = Cu_{(s)}$

16.   1998 Q7e P2

(i)   Cathode
          Hydrogen (I)

      (ii)   Anode

              Oxygen (I)

17.   **1999 Q13, Q2 P2**

      13.   (a) $2Cr\,(s) + 3Fe^{3+}\,(aq) \longrightarrow 2Cr^{3+}\,(aq) + Fe$

              (b) $0.44\text{-}E^{\circ}\,Cr\,(s) / Cr^{3+}\,(aq) + 3Fe\,(s)$
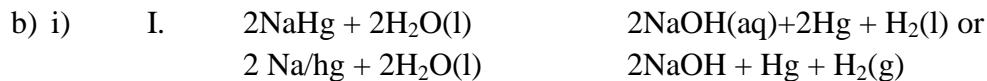
18.   **2000 Q2 P2**

     a) i)   I   Distilled water / H2O

             II   Titanium / platinum

       ii)   Chlorine / $Cl_2(g)$

       iii)   L - paper industry / Rayon manufacture/ Dyes manufacture

            -Glass industry

              - Manufacture o soaps / detergents

              - Manufacture of al from its ores.

              - Manufacture of bleaching agents

              - Manufacture of drugs / anit acid drugs.

           (Any one use = 1 mark)

           II   - To reduce running costs / make process economical

                - To avoid pollution

     b) i)   I. $2NaHg + 2H_2O(l)$ $2NaOH(aq)+2Hg + H_2(l)$ or

                  $2\,Na/hg + 2H_2O(l)$ $2NaOH + Hg + H_2(g)$

       ii) $Q = It = 100 \times 5 \times 60 \times 60 = 1800000C$

             1 Faraday forms 1 mole of Na

              1 mole of NA /Hg = 1 mole of NaOh

             NaOH = 23 + 16+ 1= 40

             96,500   40g of NaOH.

             1800000C 40 x 1800000

                      96500

                   =746.1g

19.   **2001 Q3 P2**

     (a) (i)   - G2 OR G (do not accept G⁻)

              - It has highest positive electrode potential (1 mark) or it has the

highest reduction potential (1 mark)

    (ii)   -G and N or (1mark)

           + 1.36 and -2.92 or (1mark)

           Cell (i) and (iv) (1 mark)

    (iii) $2N^+(aq) + M(s) \rightarrow 2N(s) + M^{2+}$ (aq)

        -    it cannot take place (1 mark) misbelow N in activity series (1mark) and cannot displace N from its solution (1 mark) Or

        -    It cannot take place from left to right.

           E Cell = 2.92 + 0.44 = -2.48

   E value is negative (1mark) reaction cannot take place spontaneously.

    (b)   (i) $4OH^-$ (aq) $\rightarrow O_2(g) + 2H_2O(I) + 4\ e^-$

           (1 mark for state symbols missing Eq'n not balanced = 0 mark; joining the chemicals symbols in an equation = 0 mark)

        (ii)   Insert a burning splint in a gas K. (1mark) the gas should burn with a pop sound to show it is hydrogen (½ mark)(observation and the lest are tied together)

                                                        (½ mark)

        (iii)   I.   Hydrogen is monovalent (1 mark) and oxygen is divalent or (½ mark)

                $4OH^-(aq) \rightarrow 2H_2O + O_2(g)+ 4e^-; 2H^+(aq) + 2e \rightarrow H_2(g)$ (½ mark)
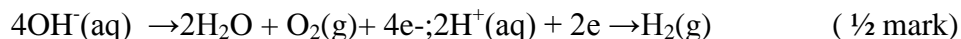
                The vol of $H_2(g)$ is twice O_2 because to produce 1 mole of $H_2(g)$2 moles of electrons required and produce 1 mole of $O_2(g)$ -4moles of electrons are given out.

           II.   The bulb is brighter with sulphuric acid. Sulphuric is a strong acid hence its degree of ionization is higher sulphuric acid is a strong acid, ethanoic acid is a weak acid

                (accept words dim, dimmer, less brighter or w.t.t.e)

20.   **2002 Q9 P1**

    (a) Displacement (1)

    (b) DGEF (1)

    (c) $G(s) + 2F^+$ (aq)

21.   **2002 Q26 P1**

    a)   Ag+(aq) + e Ag(s) (l)

    b)   Anode decreases in size/mass

        It dissolves/ions to release elections (l)   (3 marks)

22.   **2003 Q27 (P1), 2(P2)**

    27. 63.5g = 2 x 96500   1.48gm = $\dfrac{1.48 \text{ x } 2 \text{ x } 96500}{63.5}$

        1gm = 2 x 96500

        1 x 2.5 x 60 x 60 x 60 x 1   = 1.48 x 2 x 96500 q = 2.5 x 60 x 1

$$I = \frac{2 \times 1.48 \times 96500}{63.5 \times 2.5 \times 60 \times 60} \qquad\qquad I = 0.4998A \text{ or } 0.5a$$

2. a) i) On the diagram, show with a (+) sign the positive terminal

    ii) $Zn_{(s)} \longrightarrow Zn^{2+} + 2e$
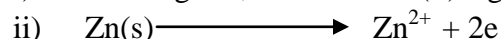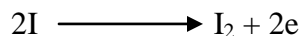
    iii)   -The cell does not produce any current// Bulb will not light // No light // ions are not mobile // the solid is a non-electrolyte.

    iv)   advantage   disadvantage

- Portable   -Not rechargeable
- Cheap   - Cannot produce continuous supply of elec.
- Convenient to use   -Environmental pollution

b)   i)   Purple /violet fumes are produced// Iodine is produced //

            $2I \longrightarrow I_2 + 2e$

     ii)   quantity of electricity $= It$

$$= 0.5 \times 2 \times 60 \times 60$$
$$= 3600$$

Mass of Pb $= \dfrac{3600 \times 207}{1.2 \times 96500}$

$$= 3.861g$$

23.   **2004 Q19 P1**

a) The colour of the solution fades (1) solution turns colorless/solid Q dissolves Brown solid is deposited on the surface of Q solid Q dissolves/diminishes/ Q goes into solution.

b) Metal Q is more reactive than Cu: displaces Cu from solution (1)   (3 marks)

24.   **2004 Q7b, c P2**

     b) i)   I   cathode: $2H^+{(aq)} + 2e \longrightarrow H_2(g)$

              II   Anode $2Cl^-(aq) \longrightarrow Cl_2(g) + 2e^-$

      ii)   I   Sodium Hydroxide/ NaOH

             II   Graphite/platinum rej carbon.

             III   sodium chloride/ NaCl

     (ii)   To prevent mixing of chlorine gas with sodium hydroxide. To allow free movement of ions. It prevents the mixing of chlorine gas and hydrogen gas.

     (c)   In paper industry

          Manufacture of soap/detergents

          Used to make bleaching agents

          Used to make bleaching agents

         Used in purification of bauxite

25.   **2005 Q3 P2**

     a) i) G^{2+}

       ii) $G_{(s)} + H^{2+}{(aq)} \rightarrow G^{2+}{(aq)} + H_{(s)}$

      iii) $E_o - E_R = \quad + 0.34 - (-0.44)$

$$= \quad 0.34 + 0.44 = 0.78 \text{ Volts}$$

b) i) H

    ii) Pure water does not contain ions or to make the water ionize

    iii) Chlorine is not used because the chlorine ions will react the electrode due to its high reactivity level.

c) 144750 Coulombs   = $\dfrac{144750 \text{ Faraday}}{96500}$

                                =   1.5 Faraday

     2 Faraday yield   =   64 g of copper

     1.5 Faradays   =   48 g copper

26.   **2006 Q15 P1**

    a) N   (1 mark)

    b) $E^{-\theta}$ =0.80 +0.76

                 = 1.56 volts   (1 mark)
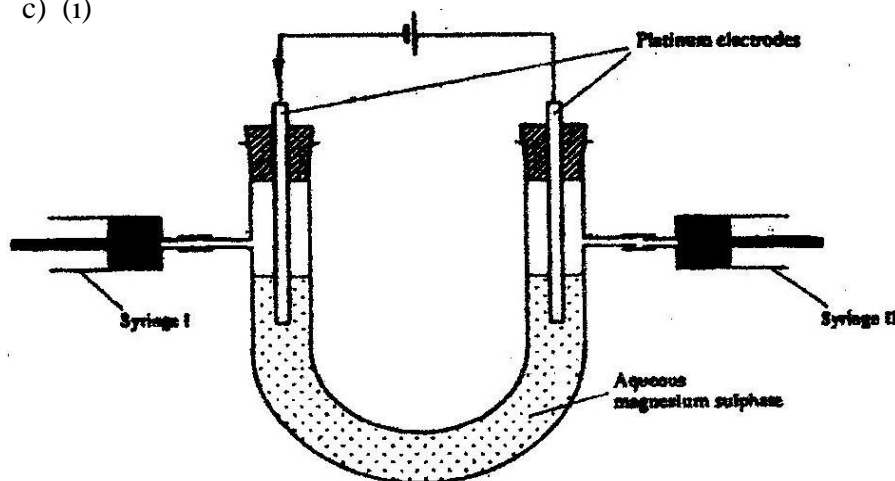
27.   **2006 Q1, 2b P2**

    a) A substance that allows the passage of an electric current and is decomposed by it.   (1 mark)

    b) (i)   Molten calcium chloride: Conducts by movement of ions.   (1 mark)

        (ii)   Graphite: Conducts by movement of ions.   (1 mark)

    c) (i)

    (ii)   Syringe. 1:   The $H+$ ions migrate to the negatively charged electrode (cathode) where they get discharged to form hydrogen gas.   (1 mark)

    d)   The amount of water used to produce O_2 and H_2 gases is **MORE** than that produced at the anode.   (2 marks)

    e)   Quantity of electricity 15 x 0.72 x 60

                               = 648 coulombs

        $4\, OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)} + 4e^-$

Faradays of electricity $\dfrac{648}{96500}$ = 0.0006715F

Moles of oxygen produced = 0.006715

= $\dfrac{0.006175}{4}$

Volume of oxygen = 0.001675x 24000

= 40.2888cm^3

= 40.29 cm^3 (4 marks)

2b) Zinc is higher than copper in the reactivity series of zinc is more reactive than copper or zinc will dissolve in the solution leading to weakening of the container or Redox reaction will take place. (2 marks)

28. 2007 Q7 P1

a)

Salt bridge
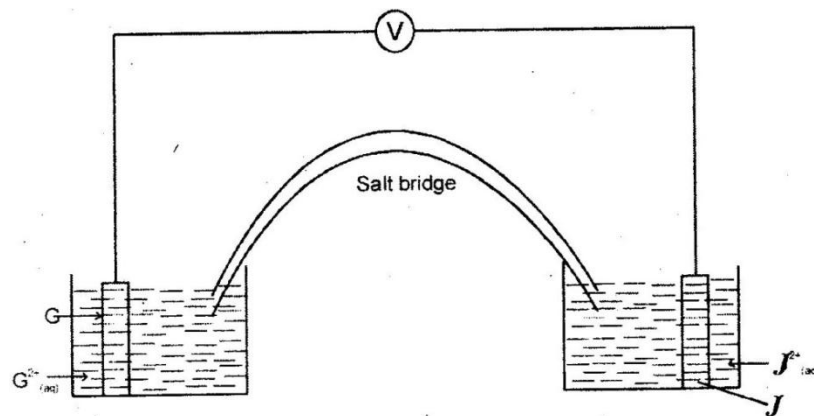
b) E^θ cell = E^θ reduced = E^θ oxidized

= -0.14V - - 0.74V = +0.6V>

29. 2007 Q21 P1

(a) Chlorine ions in Brime are high concentration compared to oxide ions in solutions

(b) Hydrogen gas

30. 2007 Q28 P1

(a) Ag(a) + e$^-$ AG(s)

(b) Ce = 1t = 5.0 x 3 x 60 = 54000c

Mass of silver deposited

= $\dfrac{108 \times 54000}{96500}$

= 60.44g

31. 2008 Q19 P1

(a) $Zn(s) / Zn^{2+}(aq) // Ag^+ / Ag (s)$

$Zn/Zn^{2+} // Ag^+/Ag(s)$

(b) The solution changes to blue because Cu metal is corroded dissolves to form Cu

32.   2008 Q21 P1

a) Cu^{2+} moving towards the cathode

b) $4OH^- (aq) - 4 e^- \rightarrow 2 H_2O (l) + O_2(g)$

   $4OH^- (aq) \rightarrow 2 H_2O (l) + O_2 (g) + 4e^-$

33.   2008 Q6 P2

(a) (i) OH^- migrate to anode, OH^- discharged to form oxygen or equation

   $4OH^-(ag) \rightarrow 2 H_2O (l) + O_2 (g) + 4e^-$

   OH oxidized to produce oxygen gas.

(ii)   Copper anode would dissolve to give CU^{2+}

   Oxidation of copper in pure energetically favorable than oxidation

   hydroxide ions

(b) (i)   Copper pyrite

   Malasclite

   Cuprite

   Chalco Pyrite

(ii) $CU^{2+}(ag) + 2e^- \rightarrow Cu(s)$

(iii)   Q= IT

   0.5 x 18 x 16 = 540c

   0.5 x 18 x 60 = 540c

   $\frac{108 \times 540}{96500}$ $\frac{540}{96500} = 0005596$

   $\frac{0.005596 \times 108}{1}$ = 0.60g

(iv)   Prevent corrosion

   Decoration/ improve appearance
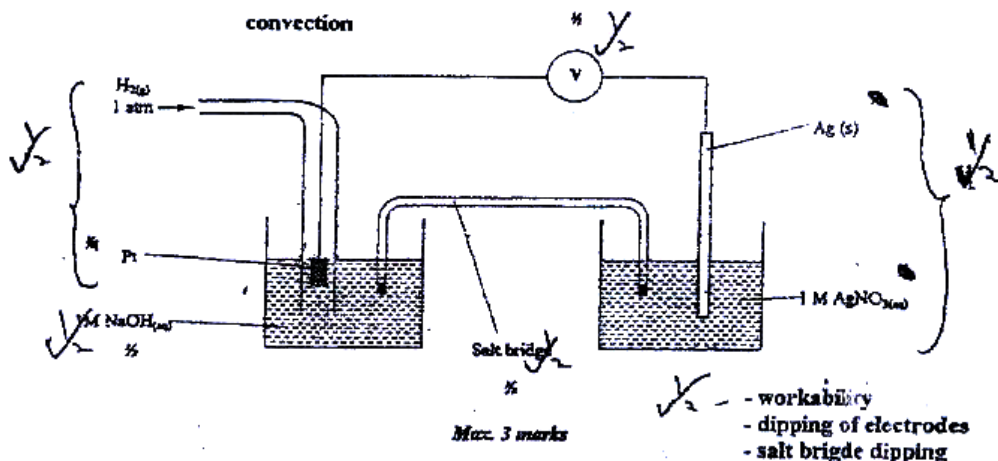
   Prevent turning of metals

34.   2009 Q7 P1

(a) $Al^{3+} + (l) + 3e^- \rightarrow AL (s) (l)$

(b) 27 g require 3 faradays (l)

   1800 x 1000g requires $\frac{3 \times 1800 \times 1000}{27}$

   $= 2 \times 10^5$ Faradays (½) = 200, 000 F   (3 marks)

35.   2009 Q10 P1

At anode $40H (aq) \rightarrow 2H_2 O_{(l)} + O_2 (g) + 4e$

At cathode $2H^+ (aq) + 2e \rightarrow H_2 (g)$ / $4N^+ (aq) + 4e^+ \rightarrow 2 Hg$

Or $4OH^-(aq) + 4 H(aq) \rightarrow 2 H_2O(l) + O_2 + (g) + 2 H_2 (g) (l)$

36.   **2009 Q12 P1**

37.   **2009 Q4 P2**

    (i) $D(l)^{2+} + 2e^- \rightarrow D(S)$ (1 mark)

    (ii) $2B+^- (l) \rightarrow Br_2 (g) + 2e^-$ (-1/2 for wrong/ missing)

    (iii)   Carbon Graphite

        It will not be attacked by/ react Bromine gas & D reacts with bromine vapours

    (iv)   Chlorine gas is poisonous/ toxic gas

38.   **2010 Q7 P1**

Answer in the Question

39.   **2010 Q19 P1**

   a) $2H_{2(g)} + O_{2(g)} \rightleftharpoons 2H_2O_{(l)}$

   b) E.m.f = 0.40 - - 0.83 = 1.23 per cell

      For ten cells = 10 x 1.23 = 12.3

   c) Water formed can be used

      Water is not a pollutant

      Don't remove harmful wastes

40.   **2010 Q1 P2**

   a) Copper chloride

      Ammonia

      They form ions when they dissolve in water. The ions conduct electricity.

   b) i) must be on the wire or metal rod

     ii) Potassium/ sodium Nitrate

                   Chloride

                   Sulphate

   c) i) To prevent it from rusting

    To improve its appearance

    To prevent conversion

    To give it shiny appearance.

    ii)

$$Q = it$$
$$= \frac{0.5 \times 60 \times 60}{96900}$$
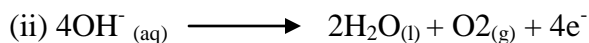$$= 2.01 \text{ g}$$

41.   2011 Q2c

Zinc reacts with cadmium ions/ displaces cadmium ions/ zinc container dissolves because zinc is more reactive / electropositive than cadmium. Zinc is a stronger reducing agent.

42.   2012 Q5 P2

(a) (i) X is the anode√1

Hydrogen gas is produced as a result of discharge of H^+ which migrate √ 1 to the cathode

(ii) $4OH^-_{(aq)} \longrightarrow 2H_2O_{(l)} + O2_{(g)} + 4e^-$

(iii) Due to the removal of water molecules / elements of water. The H^+ and OH^- which form water are discharged√1   water is electrolysed / deposited The amount of water electrolysed is more than the amount of water tamed at the anode.√1

(iv) No effect on the 60th litmus / blue remains√ blue, red remains red, the resuming solution is neutral√

(b) Calculating A to discharge 1mole (24dm^3)

Converting C to F √ ½ Q = 1t √ ½
Converting F to moles   = 0.3 x 30 x 60
Converting moles to volume = 540C√

$24dm^3 \longrightarrow 96500 \times 4C$

$? \longrightarrow 540C√1$
$= 0.033575dm√1$

(c) - extraction of very reactive metals e.g Na and Al
    - used in electroplating   ½ mark each
    - use in refining of metals e.g cu
    - anoding of aluminium
        Rej – extraction of metals / reactive metals

43.   2012 Q15 P1

(a) salt bridge

(b) emf $= E^\theta$red $- E^\theta$oxid

       $= -0.80 - (-0.13)$ or 0.13-18

       $= -0.670v$

      OR

Emf $= E^\theta$red $- E^\theta$oxid

       $= -013 - (-0.8)$ or -13+0.8

       $= +0.670v$

        Or

Emf $= +0.80 - (-0.13)$

   Or $0.80 + 0.13$

     $= +0.93v$

44. 2012 Q28 P1

(a) $2Cl^- \longrightarrow Cl_{2(g)} + 2e^-$

   Or $2cl^-_{(aq)} - 2e \longrightarrow Cl_{2(g)}$
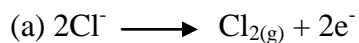
   NB. Penalise state symbols / balance

(b) O_2 / oxygen

  - OH^- ions will be in higher concentration

   OH^- being higher in the electromotive series than the chloride ions hence

     preferentially discharged or OH^- has a higher –ve potential