Electrochemistry

1. i) Carbon – carbon/ platinum – carbon

   ii) - The concentration of magnesium sulphate increase

   - Hydrogen and oxygen given off at the electrodes reduce the water content

2. $Cu^{2+} + 2c- \_\_\_\_\_ Cu_{(s)}$

   Mass =

   $$1.48 = \frac{63.5 \times I \times 2.5 \times 60}{2 \times 96500}$$

   $$I = \frac{1.48 \times 2 \times 96500}{63.5 \times 2.5 \times 60}$$

   $$= 29.988\ A$$

3. a) Anode is electrode A (1 mk)

   B is cathode

   b) $2H^{+}_{(aq)} + 2e- \_\_\_\_\_ H_{2\,(g)}$

   c) The acid becomes more

4. i) $200 \times 58 \times 60\ C \_\_\_\_\_ 64.8g$ √ ½

   $9500C \_\_\_\_\_ 27g$ √ ½

   $$\frac{27 \times 200 \times 58 \times 60}{64.8 \times 96500}$$ √ ½ $= +3$ √ ½

   ii) $40H-_{(g)} \_\_\_\_\_ 2H_2O_{(L)} + O^2_{(g)} + 4e^-$ √ ½

   $4 \times 96500 \_\_\_\_\_ 22.4dm^3$ √ ½

   $$\frac{200 \times 58 \times 60 \times 22.4}{4 \times 96500\ C}$$

   $= 40.39dm^3$ √ ½

5. a) $Mg_{(s)} + Pb^{2+}_{(aq)} \_\_\_\_\_ Mg^{2+}_{(aq)} + Pb_{(s)}$

   b) $0.13 - (-0.76)$

   $= +0.53V$

6. (a) $2F = 10 \Rightarrow 2F - 10 = 0;\ 2F = 10 \quad \therefore F = +5$

   $F = +5$ (penalize -5)

   (b) Group VI

7. Aluminium has a higher electrical conductivity than sodium. √ Aluminium has three delocalized √½ electrons in its metallic structure while sodium has only one delocalized electron in its structure. √½

8. $Q = It$ √½

   $= 3 \times 50 \times 60$ √½

   $= 9000\ C$ √½

   1 mole of Zn is liberated by a charge of 2 f.

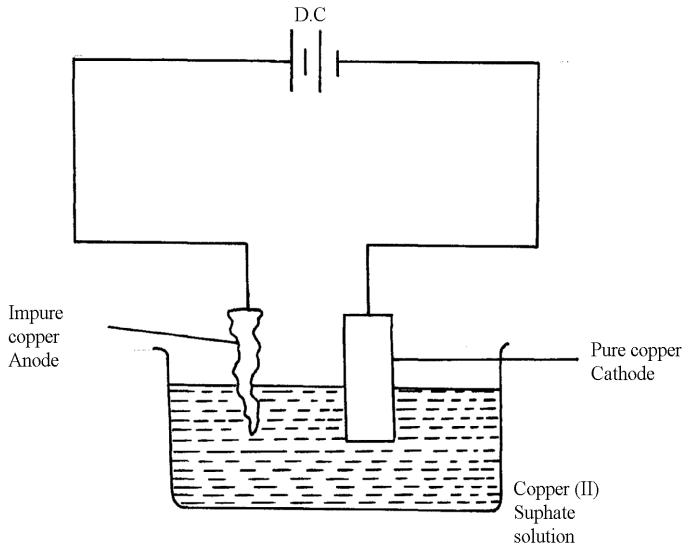
   i.e 96500 x 2 x 65g of Zn

   9000C ?

$= \underline{65 \times 9000} \checkmark^{1} = 12.124g\ Zn \checkmark^{½}$
96500×2

9. a) Q is sulphur (IV) oxide $SO_2(g)$. $\checkmark^{1}$

b)



- Impure copper is the while pure copper is cathode. During electrolysis impure copper is purified and pure copper deposited on the cathode as shown in the half electrode reaction below;

<u>CATHODE EQUATION:</u>

$Cu^{2+} + 2e \quad Cu(s)$ $\checkmark^{½}$

- The cathode is therefore removed and replaced after an interval.

10. a) i) the yield of NH_3 would be lowered ✓½ any supply of heat makes NH_3 to decompose to N_2 and H_2

ii)the yield of NH_3 would be increased

b)a catalyst accelerate the rates of both forward and reverse reactions equally✓½ . Equilibrium position is not affected by a catalyst✓½

c)

11. a)T✓

b)$Z_S + 2G^{+} \qquad 2G_{(S)} + Z_{(aq)}^{2+}$✓1

c)$E^{\theta}cell = E - E$

$= 0.08 - (-2.38)$✓1

$= \underline{+ 3.18}$

12. Mass of due to C = $\frac{12}{44}$ x 4.2 = 1.145✓½

Mass of due to H = $\frac{2}{18}$ X 1.71 = 1.889✓½

Moles of C = $\frac{1.145}{12}$ = 0.095✓½

Moles of H = $\frac{0.1889}{1}$ =0.1889✓½

Moles ratio c: r

0.095: 0.1889✓½

1: 2

E.F = CH_2✓½ (accept alternative method)

13. 96,500 coulombs 1 faraday

144,750 ,, ?

$\frac{144,750}{96,000}$ faraday✓½

= 1.5 faradays✓½

Copper (II) ions = 2 faradays (penalize ½ mk for missing/wrong units)

2 faradays yield = 64g of copper

1.5 faradays yield = ?

= $\frac{1.5}{2}$ x 64g✓½

=48g of copper was obtained✓½

14. Physical difference:-

Na_2O_2 – yellow while Na_2O is white

Chemical difference:-

N_2O_2 reacts with water to form NaOH and O_2 while ✓ 1

Na_2O reacts with water to form NaOH only ✓ 1

15. (a) $Pb(NO_3)_2$

(b)

(c) $Mg_{(s)} / Mg^{2+}{}_{(aq)} // Pb^{2+}{}_{(aq)} / Pb_{(s)}$

16. (a) MnO_4 is reduced;

Oxidation number of Mn is reduced from +7 to +2

(b) $5Fe^{2+}_{(g)}$ $5Fe^{3+}_{(aq)} + 5e.$;

17. *i)* $2Cr_{(S)}$ _____ $2Cr^{3+}_{(aq)} + 6e$

$3Fe^{2+}_{(aq)} + 6e$ _____ $3Fe_{(g)}$

$2Cr_{(g)} + 3Fe^{2+}_{(aq)}$ _____ $2Cr^{3+}_{(aq)} + 3Fe_{(g)}$ ✓

ii) $0.30 = - 0.44 - E^{\ominus}_{R}$

$E^{\ominus}_{R} = - 0.44 - 0.30$

$= - 0.74V$ ✓

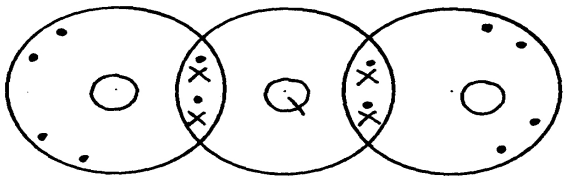
18. *(a) – Filtration of air/electrostatic precipitation/purification*
- Passing through sodium hydroxide/potassium hydroxide to absorb Carbon (IV) oxide gas ✓1/2
- Cool to remove water vapour as ice ✓1/2
-Cool remaining air to liquid by repeated compression and expansion of liquid air ✓1
- Fractional distillation of liquid air- Nitrogen collected at -196°C ✓1
(b) (i) Nitrogen (II) Oxide
(ii)

$NH_{3(g)} + CuO_{(s)}$ $N_{2(g)} + H_2O_{(l)} + Cu_{(s)}$

OR - Oxidation number of N_2 in NH_3 increases from -3 to 0. Oxidation number of reducing agent increases or oxidation number of Cu in CuO decreases from +2 to 0 hence is a reducing agent

(iii) NH_4NO_3 $N_2O + 2H_2O$
(iv) Fertilizer/expose
(c) (i) G or G
(ii) $E^{2+}_{(aq)} + 2OH^{-}_{(aq)}$ $E(OH)_{2(s)}$

19. *a) i)* G// $G_{2(g)}$ *Not* G^{-}
It has the highest potential OR highest reduction potential ✓*1 mark*
ii) G and N or $G_{2(g)}$ // $N_{(g)}$ ✓*1 mark*
iii)



20. *a) (i) Cathode – steel*
Anode – Carbon / graphite
(ii) To lower the melting P^{+} *hence reducing cost of heating the salt.*
(iii) To prevent the two products from recombining.
(iv) Cathode
$Na^{+}_{(l)} + e^{-}$ $Na_{(l)}$
Anode
$2Cl^{-}_{(l)}$ $Cl\ 2_{(g)} + 2e^{-}$
(v) less dense than electrolyte/ has low density

b) (i) quantity = 6.42 X 10 60 = 3852

(ii) 3852c province 2.74

2X 96000 " (2 X 96000) X 2.74 / 3852

= 136.58

21. .a) i) $H^{+}_{(aq)} + e^{-}$ ½ H_2

ii) E cell = 0.76 + 0.54 = +1.3 volts

iii) I. Fe^{3+}

II. Zn

IV. Fe^{3+} ion

$2\ Fe^{3+} + 2\ e^{-}$ $2\ Fe^{2+}$ $E^{0} = +0.77$

$2\ I$ $I_{2g} + 2e$ $E^{0} = -0.54$

$2\ Fe^{3+}_{(aq)} + 2I_{(aq)}$ $2Fe^{2+}_{(aq)} + I_2$ $E^{0} = +0.23$

22. a) i) Chlorine Has a higher reduction potential

ii) +1.36 2.36 = +3.72

b) i) P and S

ii)

iii) +1.50 – 0.44 + + 1.94

c) Q = 4 X a6 X 60 = 3840C

1.17g _____ 3840

59 g _____ 59 X 3840 / 1.174 = 192981.261 C

If 96,500c _____ IF

192891.261 _____ 192981.261 X 1 / 96500

Charge of X = +2

Formula $X(NO_3)_2$

23. (a) B – Copper metal

C – Chlorine gas

D – Ammmonia gas

E – Zinc

(b) (i) $Cu^{2+}_{(aq)} + 2e^{-}$ $Cu_{(s)}$

(ii) $CuSO_4 + Zn_{(s)}$ $ZNSO_4 + Cu_{(s)}$

$Cu^{2+} + Zn_{(s)}$ $Cu_{(s)} + Zn^{2+}_{(aq)}$

(c) – Water treatment

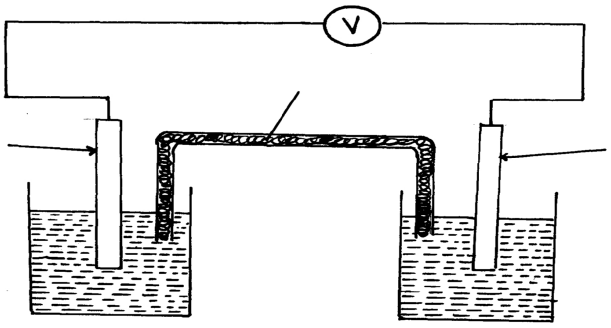
-Manufacture of hydrochloric acid

(d) Tetra mine copper (II) ions

24. (a) (i) $E^{\theta} = 1.13V$

(ii) T_2 because it's standard electrode potential is zero. i.e. point of reference.

(iii)



(iv) E.m.f = + 1.23 - - 0.76 = 1.99 V

(b) (i) x - Oxygen
y – Hydrogen

(ii) $4OH^-_{(aq)} \quad 2H_2O + O_2 + 4e$

(iii) Reduction takes place at electrode Y. H^+ ions gain electrons to form hydrogen gas.

(iv) Platinium / graphite/ Nickel because it is inert.

25. *(i)* $Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \quad Zn(OH)_{2(s)}$

$Zn(OH)_{2(s)} + 4NH_{3(aq)} \quad Zn(NH_3)4\ ^{2+}_{(aq)} + 2OH^-_{(aq)}$

(ii) The mixture consists of a soluble compound and an insoluble compound.
(iii) Evolution brown fumes of NO_2 gas
(iv) CO_3^{2-} - Because its reaction with HNO_3 produces CO_2 gas or $2H^+_{(aq)} + CO_32-_{(aq)}\ H_2O_{(l)} + CO_{2(g)}$
(v) Pb^{2+} ion
(vi) Lead (ii) Carbonate
Zinc (II) Nitrate

26 *A (i) Process by which an electrolyte is decomposed by passing an electric current through it.*
(ii) Anode – left pt rod
Cathode – right pt rod
(iii) – Blue /pale green colour fades
- P solution becomes acidic

B (i) a. – D^{2+}
b. – D^{2+}
(ii) C

$$E_{cell} = E_{ordn} - E_{ordn}$$
$$= +0.34 - (-2.92) = +3.26V$$

(iii) $B_{(s)} / B^{2+}_{(aq)} // D^{2+}_{(aq)} / D_{(s)}$; $E = + 3.26V$

27 $Q = 40000 \times 60 \times 60 = 144000000c$

$$\text{Mass of Al} = \frac{144000000 \times 27}{3 \times 96500} \quad \checkmark 1$$
$$= 13.43kg \quad \checkmark 1$$

28. *a) Strip of copper metal dissolved forming blue solution. ✓½*

b) Copper displaces ions ✓½ of Q from solution since copper is more electropositive ✓½ than Q.

c) E.m.f of cell = (0.80 - 0.34)V √½

= 0.46V √½

29 (a) (i) Carbon (IV) Oxide gas evolved was lost to the atmosphere

(ii) Concentration of reactants higher between O and R

Reaction rate faster

(iii) Grinding the marble chips

(iv) Calcium sulphate

(v) Plaster of Paris

(b) (i) Hydrogen ions discharged;

It takes less energy than calcium ions

(ii) $2Cl^-_{(aq)}$ $Cl_{2\ (g)} + 2e$

(iii) Q = 1t = 4 x 1 60 x 60 (½ mk)

= 14400C

2 x 96500C = 2 x 35.5 (½mk)

$$14400C = \frac{14400 \times 2 \times 35.5}{2 \times 95600}$$

= 5.297g (½mk)

30. a) the bulb light√ ½

Hydrogen chloride gas ionized in water to give H^+ and cl^-(aq) that are responsible for conduction of electric current√1

b)$2H^+(aq) + ze^-$ $H_2(g)$√1

31. Q = it IF = 69500C 2F _____ 206g of Pb

= 40x(5x60) = $\frac{1200x1}{96500}$ F = $\frac{0.01243}{2F}$ x 206

= 1200 C = 0.01245 F = 1.280g

b) I $K_{(s)}$_____ $K^{2+}_{(aq)} + 2e^-$

Na+ 2e _____ $N_{(g)}$

II 1. Salt bridge

2. Complete the circuit

Balance the ions in each half cell

III

IV E cell = E Red – E oxd

= +1.16 – (-0.17) = +1.33V

32. (a) (i) Zinc sulphate / Zinc chloride / Zinc nitrate solution

(ii) Copper

(iii) $Zn_{(s)} + Cu^{2+}_{(aq)}$ $Zn^{2+}_{(aq)} + Cu_{(s)}$

(iv) E = 0.34 + 0.76

= 1.0V

. (b) (i)Concentrated sodium chloride solution

(ii) $2\ Cl^-(aq)$ $Cl_{2(g)} + 2e$

$Na^+(aq) + e$ $N_{(l)}$

(iii) Sodium amalgam is flown into water. It reacts forming sodium hydroxide solution

33. *Quantity of electricity = (40,000 X 60 X 60) Coulumbus √½ mark*
3 x 96,500 Coulumbus produce 27g of Al

$\therefore \frac{40,000 \times 60 \times 60 \times 27}{3 \times 96,500 \times 1000}$ Kg √½ mark
√½ mark
= 13.43Kg √½ mark
Subtract ½ mark if units missing or wrong
[Total 12 marks]

34. *i) Increased yield of NO/ √1 mark Equilibrium shifts to the right // favours the forward reaction// reduced pressure favours forward reaction// increased volume number of molecules*

ii) It will not affect the yield // remains the same
Catalyst do not affect position of Equilibrium

35. *a) R*
b) T
c) i) $T_{(g)}$ and $S_{(g)}$

ii) Half cell one *Half cell two*
T(s) – 2e-____ T2+ *S2+(aq) + 2e _____ S(s)*
OR: T(s) ____ $T2+_{(aq)}$ + 2e-

iii) $T_{(s)}$ _____ $T^{2+}{}_{(aq)}$ + 2e, E = +0.74V

iv) From T(s)/ T2+ half cell to S2+/ S(s) half cell through conducting wires

d) i) Q = It
= 2.5 x (15x60)
= 2250C

ii) RAM = $\frac{\text{mass x valency x 96500}}{Q}$
= $\frac{0.74 \times 2 \times 96500}{2250}$
= $^{142820}/_{2250}$
= 63.476

36. *a) R*
b) T
c) i) $T_{(g)}$ and $S_{(g)}$

ii) Half cell one *Half cell two*
T(s) – 2e-____ T2+ *S2+(aq) + 2e _____ S(s)*
OR: T(s) ____ T2+(aq) + 2e-

iii) $T_{(s)}$ _____ T^{2+} (aq) + 2e, E = +0.74V

iv) From T(s)/ T2+ half cell to S2+/ S(s) half cell through conducting wires

d) i) Q = It
= 2.5 x (15x60)
= 2250C

ii) RAM = $\frac{\text{mass x valency x 96500}}{Q}$

= $\frac{0.74 \times 2 \times 96500}{220}$

= $^{142820}/_{2250}$

= 63.476

37. *NH^+_4✓1, proton donor✓*

38. *a) - Bubbles of colourless gas at the anode✓½*
- Brown deposits at the cathode ✓½
- Blue color of the solution fades *Any 2 ½ mark each*

b) The Ph decreases
Removal of OH^- ions leaves an excess of H^+ hence the solution becomes more acidic✓

39. *a) Anode. Copper anode dissolves*
b) Q = 0.5 X 60 X64.3 = 1929C
0.64g of Cu _____ 1929 C
∴ 63.5 of Cu
$\frac{63.5 \times 1929}{0.64}$✓½
= 191393 C ✓½

40. *The grey-black solid changes to purple gas iodine sublimes at low temperature due to weak Van der walls forces*

41. *(a) The mass of substance liberated during electrolysis is directly proportional to the quantity of electricity passed*
(b) Quantity of electricity = 2 x 2 x 36000 = 14400c (½mk)
Volume of gas evolved = $\frac{14400 \times 22.4}{2 \times 96500}$ = 1.671dm³ (1 ½ mk)

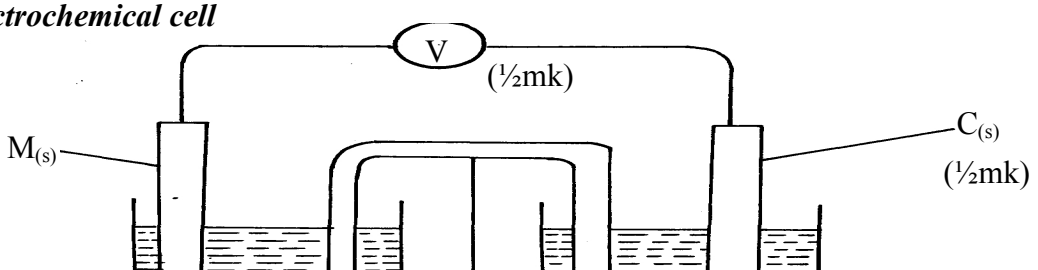
42. *(a) OH^- √1 (1 mk)*

43. *(i) ZnS- No mark if the letters are joined*
(ii) SO_2 produced as a by-product is used in contact process to obtain H_2SO_4. This acid is used in making fertilizers e.g. ammonium sulphate
✓1

44. *(i) CaO is basic and P_4O_{10} is acidic*
(ii) Let the ON of P be x
4x + (-2 x10) = 0
$\frac{4x}{4} = \frac{+20}{4}$ ✓ ½
x = +5
(iii) Used as a fertilizer ✓1
✓1

45. *Platinum electrode is used, H_2 is bubbled over the pt electrode immersed in 1M H+ i.e 1M HCl. The electrode is coated with finely –divided platinum catalyst*

(b)electrochemical cell



(½mk) $C^{2}{}_{(aq)}$

$M^{2+}{}_{(aq)}$

46. ***+ 0.76 + 0.34 = 1.0Volts*** (½mk)

47. ***(a) - Red- Phosphorous***

- White – Phosphorous

(b) Phosphorous is insoluble in water because its non-polar while water is polar.

It cannot be stored in oil because oil is non-polar it will dissolve the phosphorous.

48. ***(a)*** $2X_{(s)} + 3W(aq) \quad 2X^{3+}_{(aq)} + 3W_{(s)}$

(b) $E^{\theta}(X/X^{3+}_{(aq)} + - 0.44 = 0.3V$

$E^{\theta}(X_{(s)}/X^{3+}_{(aq)} = +0.74V$ ✓

$E^{\theta}(X^{3+}_{(aq)})/X_{(s)} = -0.74V$ ✓

✓ ½ ✓ ½

Salt bridge

49. ***Electrode - E_1 is the anode***

Dilute electrolyte – OH^- ions are discharged.

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

Oxygen gas is produced.

Discharge of hydroxyl ion increases the concentration of sodium chloride.

Chloride, Cl^- are then discharged.

Chloride, Cl-, are then discharged

Chloride gas is produce

$2Cl^-_{(aq)} \quad Cl_{2(g)} + 2e^-$

50. ***a)*** $C10_3^-$ (=) Cl + 3(-2) = -1(=)Cl -6 =-1,Cl= + 5

$\overset{+5}{C}l0_3^-{}_{(aq)}\ 6H^+_{(aq)} + 5e^- \quad \overset{0}{Cl}_{2(g)} + 3H_2O_{(l)}$

b) NO^-_2 (=) N+2 (-2) = -1(=) N-4 = -1 (=) = N+ 3

$NO^-_2 + H_2O_{(l)} \quad NO^-_{3(aq)} + 2H^+_{(aq)} + 2e^-$

51.

Half Cell $E^{\theta}/_V$		***$E^{\theta}/_V$ using iron ref - electrode***
$Al_{(s)}/Al^{3+}_{(aq)}$	- 1.66	- 1.22
$Zw_{(s)} / Zn^{2+}_{(aq)}$	- 0.76	+0.32
$Fe_{(s)}/Fe^{2+}_{(aq)}$	- 0.44	0.00
$Ni_{(s)}/Ni^{2+}_{(aq)}$	- 0.25	+ 0.19

52. $\theta = 1.5 \times 60 \times 15 = 1350$

$J^{3+}_{(aq)} + 3e^- \quad J_{(s)}$

$3F = 3 \times 96500 = 289\ 500C$

$289500C$ deposit = 52g of $J_{(s)}$

$= 1350$ C deposit $= \frac{1350 \times 52}{289500} = 0.2\ 2425g$

53. ***Tin (Sn) its oxidation potential is +0.144V. It is the least likely to combine/ react with elements of weather***