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

   4×96500 _____ $22.4dm^3$ √ ½

   $$\frac{200 \times 58 \times 60 \times 22.4}{4 \times 96500\ C}$$
   $= 40.39dm^3$ √ ½
5. a) $Mg_{(s)} + Pb^{2+}_{(aq)} \_\_\_\_\_ Mg^{2+}_{(aq)} + Pb_{(s)}$

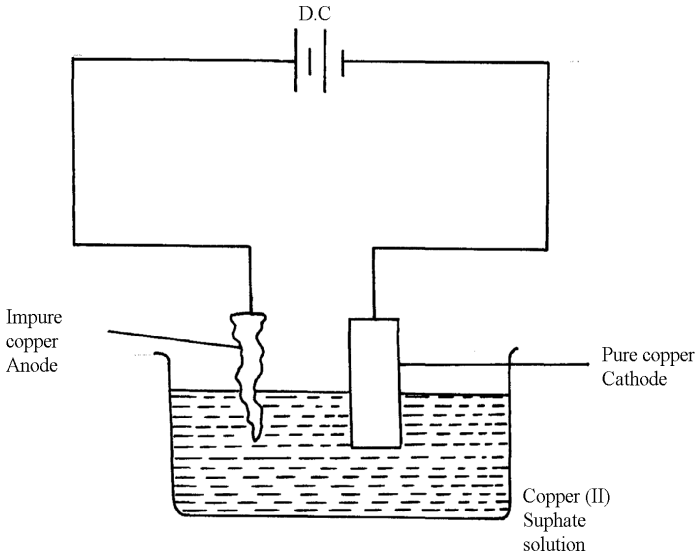
   b) $0.13 - (-0.76)$
   $= +0.53V$
6. (a) $2F = 10 \Rightarrow 2F - 10 = 0;\ 2F = 10 \quad \therefore F = +5$
   $F = +5$ (penalize -5)
   (b) Group 1V

7. Aluminium has a higher electrical conductivity than sodium. √1 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 $96500 \times 2 \times$ ⟶ $65g$ of Zn
   $9000C$ ⟶ ?
   $= \frac{65 \times 9000}{96500 \times 2}$ √1 $= 12.124g\ Zn$ √½

9. a) Q is sulphur (IV) oxide $SO_2(g)$. √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;

CATHODE EQUATION:

$Cu^{2+} + 2e \longrightarrow Cu(s)$ √½

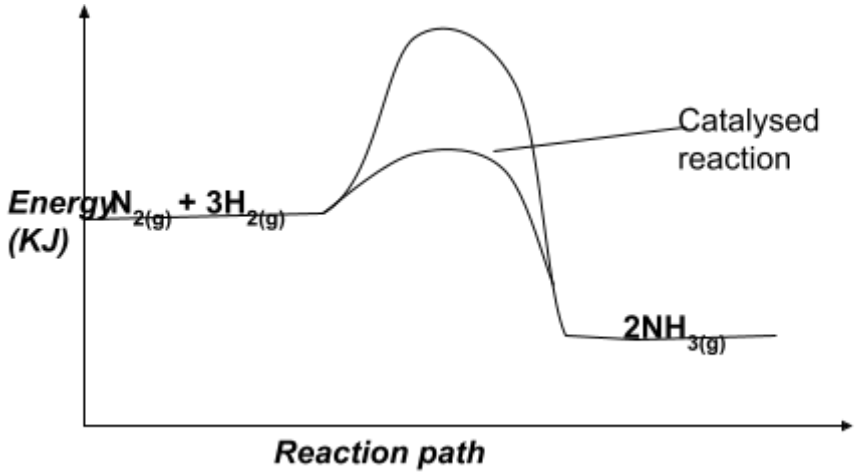
- The cathode is therefore removed and replaced after an interval.

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)$Z_S + 2G^+ \longrightarrow 2G_{(S)} + Z_{(aq)}^{2+}$ √1

c)E^0 cell = E - E

= 0.08 – (-2.38)√1

= + 3.18

12. Mass of due to C = 12 x 4.2 = 1.145√ ½

$$\text{Mass of due to H} = \frac{44}{18} \times 1.71 = 1.889\surd\ ½$$

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

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

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 ,, ——————→ ?

144,750 faraday√ ½

96,000

= 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 = ?

$= \frac{1.5}{2} \times 64g\surd\ ½$

=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) $5Fe^{2+}_{(g)} \longrightarrow 5Fe^{3+}_{(aq)} + 5e^-$;

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

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

$= -0.74V$ √

18. (a) – Filtration of air/electrostatic precipitation/purification

- Passing through sodium hydroxide/potassium hydroxide to absorb Carbon (IV) oxide gas ½
- Cool to remove water vapour as ice
- Cool remaining air to liquid by repeated compression and expansion of liquid air ½
- Fractional distillation of liquid air- Nitrogen collected at -196°C ½

(b) (i) Nitrogen (II) Oxide

(ii) Oxidation

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

-3 → 0 (+3) ; 0 (+2)

Reduction

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

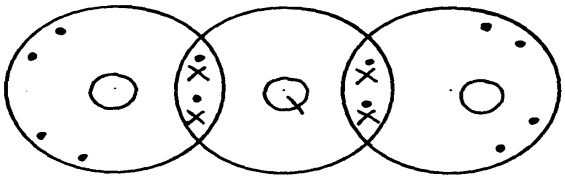
(ii) $E^{2+}_{(aq)} + 2OH^{-}_{(aq)} \longrightarrow E(OH)_{2(s)}$

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

$Na^{+}_{(l)} + e^{-} \longrightarrow Na_{(l)}$

Anode

$2Cl^{-}_{(l)} \longrightarrow Cl\ 2_{(g)} + 2e^{-}$

(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) $H^+_{(aq)} + e^- \rightleftharpoons \frac{1}{2} H_2$

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

iii) I. Fe^{3+}

II. Zn

IV. Fe^{3+} ion

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

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

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

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) $Cu^{2+}_{(aq)} + 2e^- \longrightarrow Cu_{(s)}$

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

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

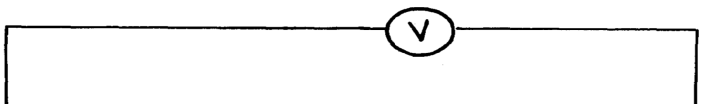
(c) – Water treatment

-Manufacture of hydrochloric acid

(d) Tetra mine copper (II) ions

24. (a) (i) E^0 = 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) $4OH^-_{(aq)} \longrightarrow 2H_2O + O_2 + 4e$

(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) $Zn^{2+}_{(aq)} + 2OH^-_{(aq)} \longrightarrow Zn(OH)_{2(s)}$

$Zn(OH)_{2(s)} + 4NH_{3(aq)} \longrightarrow Z[\quad]_{(aq)} + 2OH^-_{(aq)}$

(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 x 60 x 60 = 144000000c

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

$$= 13.43kg \quad 1$$

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) $2Cl^-_{(aq)} \longrightarrow Cl_{2\,(g)} + 2e$
(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) $2H^+(aq) + ze^- \longrightarrow H_2(g)$*√1*

31. Q = it IF = 69500C 2F _____ 206g of Pb
= 40x(5x60) = 1200x1 F = 0.01243 x 206
= 1200 C 96500 2F
= 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) $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$
(iv) E = 0.34 + 0.76
= 1.0V

. (b) (i)Concentrated sodium chloride solution
(ii) $2\,Cl^-(aq) \longrightarrow Cl_{2(g)} + 2e$
$Na^+(aq) + e \; N_{(l)}$
(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 = $\frac{14400 \times 22.4}{2 \times 96500}$ = $1.671dm^3$ (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

$4x + (-2 \times 10) = 0$

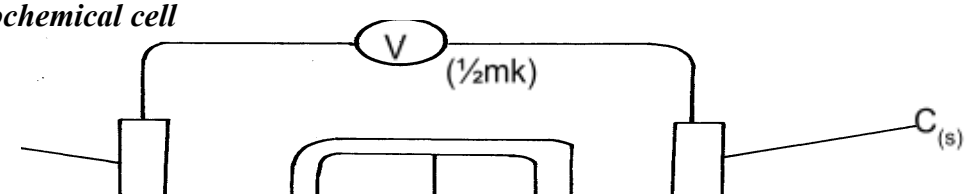
$\frac{4x}{4} = \frac{+20}{4}$ ½

$x = +5$ 1

(iii) Used as a fertilizer 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 1

(b)electrochemical cell



$M_{(s)}$ (½mk)

(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.

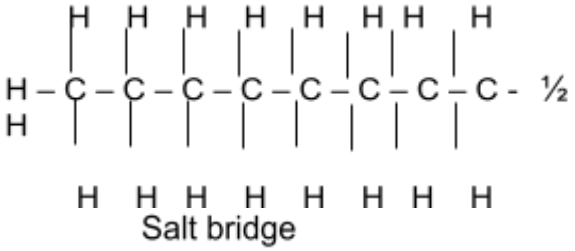
48. (a) $2X_{(s)} + 3W(aq) \longrightarrow 2X^{3+}_{(aq)} + 3W_{(s)}$

(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

49. Electrode - E_1 is the anode

Dilute electrolyte – OH^- ions are discharged.

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

Oxygen gas is produced.

Discharge of hydroxyl ion increases the concentration of sodium chloride.

Chloride, Cl^- are then discharged.

Chloride, Cl-, are then discharged

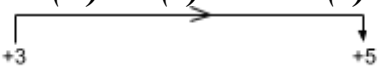
Chloride gas is produce

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

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

$C10_3^-{}_{(aq)}\ 6H^+_{(aq)} + 5e^- \longrightarrow Cl_{2(g)} + 3H_2O_{(l)}$

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



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

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

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

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

$289500C$ 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