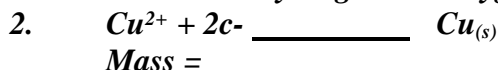


Electrochemistry

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

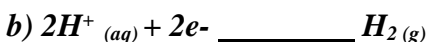


$$1.48 = \frac{63.5 \times I \times 2.5 \times 60}{2 \times 96500}$$

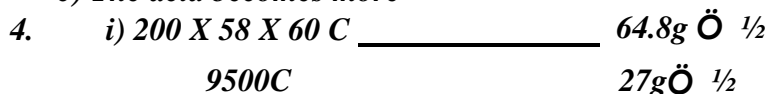
$$I = \frac{1.48 \times 2 \times 96500}{63.5 \times 2.5 \times 60}$$

$$= 29.988 \text{ A}$$

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



c) The acid becomes more



$$\frac{27 \times 200 \times 58 \times 60}{64.8 \times 96500} \ddot{O}^{1/2} = +3 \ddot{O}^{1/2}$$



$$4 \times 96500 \rightarrow 22.4 \text{ dm}^3 \ddot{O}^{1/2}$$

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



b) $0.13 - (-0.76)$
 $= +0.53 \text{ V}$

6. (a) $2F = 10 \rightarrow 2F - 10 = 0; 2F = 10 \rightarrow F_{P1} = +5$
 $F = +5$ (penalize -5)
- (b) Group V₁

7. *Aluminium has a higher electrical conductivity than sodium. ¹ Aluminium has three delocalized ^{1/2} electrons in its metallic structure while sodium has only one delocalized electron in its structure. ^{1/2}*

8. $Q = It$ ^{1/2}
 $= 3 \times 50 \times 60$ ^{1/2}
 $= 9000 \text{ C}$ ^{1/2}

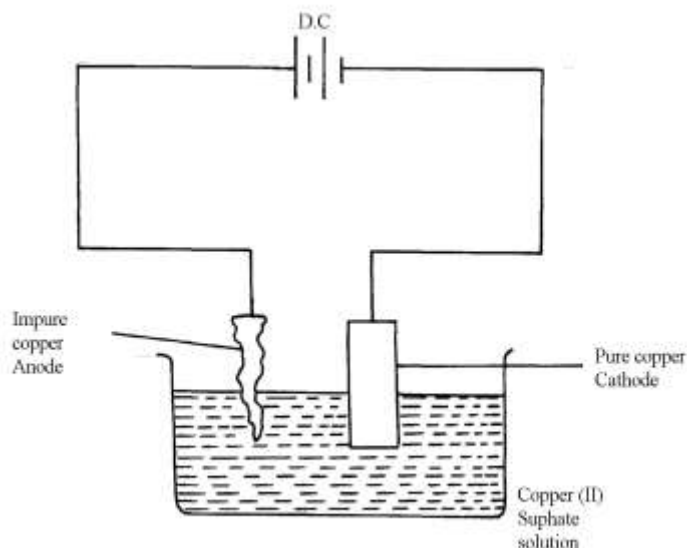
1 mole of Zn is liberated by a charge of 2 f.

i.e 96500 x 2 x 65g of Zn
9000C ?

$$= \frac{65 \times 9000}{96500 \times 2} \sqrt{t} = 12.124g \text{ Zn } \sqrt{t}$$

9. a) Q is sulphur (IV) oxide $SO_2(g)$. \sqrt{t}

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:



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

10. a) i) the yield of NH_3 would be lowered \sqrt{t} 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 \sqrt{t} . Equilibrium position is not affected by a catalyst \sqrt{t}

c)

11. a) $T\mathcal{V}$

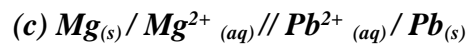
b) $Z_S + 2G^+$

$2G_{(s)} + Z_{(aq)}^{2+}\mathcal{V}I$

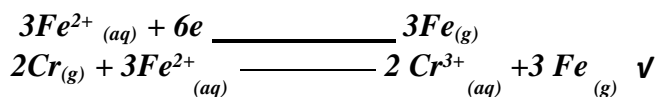
c) $E^{\circ} cell = E - E$

$$= 0.08 - (-2.38)\mathcal{V}I$$

$$= \underline{+3.18}$$



16. (a) MnO_4 is reduced;
Oxidation number of Mn is reduced from +7 to +2



ii) $0.30 = -0.44 - E^{\circ}_R$

$$E^{\circ}_R = -0.44 - 0.30$$

$$= -0.74V \quad \checkmark$$

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

- Passing through sodium hydroxide/potassium hydroxide to absorb Carbon (IV) oxide gas

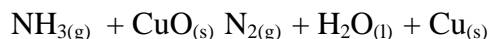
- Cool to remove water vapour as ice

- Cool remaining air to liquid by repeated compression and expansion of liquid air

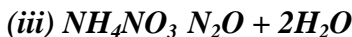
- Fractional distillation of liquid air- Nitrogen collected at $-196^{\circ}C$

(b) (i) Nitrogen (II) Oxide

(ii)

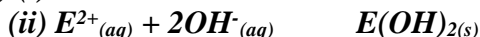


OR - Oxidation number of N_2 in NH_3 increases from -3 to 0. Oxidation number of reducing agent increases or oxidation number of Cu in CuO decreases from +2 to 0 hence is a reducing agent



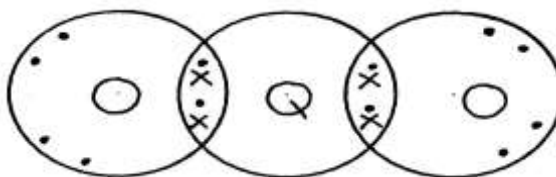
(iv) Fertilizer/expose

(c) (i) G or G



19. a) i) G // $G_{2(g)}$ Not G

It has the highest potential OR highest reduction potential Ö 1
 mark ii) G and N or $G_{2(g)} // N_{(g)}$ Ö 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



Anode

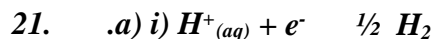


- (v) less dense than electrolyte/ has low density

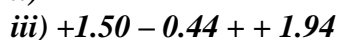
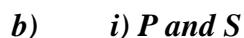
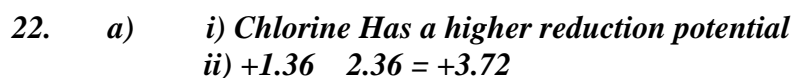
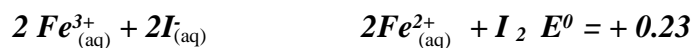
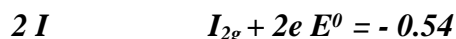
b) (i) $quantity = 6.42 \times 10^6 = 3852$
 (ii) $3852c \quad province \ 2.74$

$$\frac{2 \times 96000 \times (2 \times 96000) \times 2.74}{3852}$$

$$= 136.58$$



ii) $E_{cell} = 0.76 + 0.54 = +1.3 \text{ volts}$



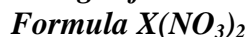
c) $Q = 4 \times 6 \times 60 = 3840C$

$1.17g \quad \frac{3840}{59}$

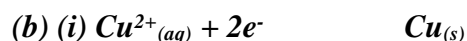
$59g \quad \frac{59 \times 3840}{1.174} = 192981.261 C$

If 96,500c $\frac{192981.261}{96500} \times 1$

Charge of X = +2



23. (a) B – Copper metal
 C – Chlorine gas
 D – Ammonia gas
 E – Zinc





(c) – *Water treatment*

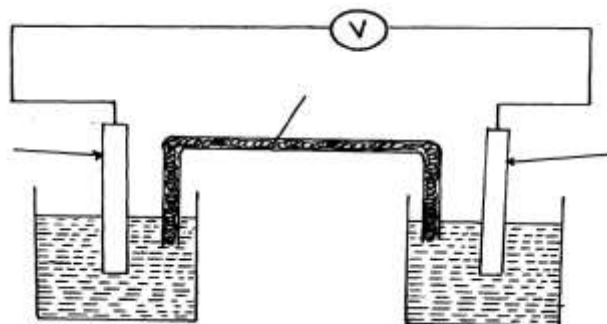
– *Manufacture of hydrochloric acid*

(d) *Tetra mine copper (II) ions*

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

(ii) T_2 because its 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



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

(iv) *Platinum / graphite/ Nickel because it is inert.*



(ii) *The mixture consists of a soluble compound and an insoluble compound.*

(iii) *Evolution brown fumes of NO_2 gas*



(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

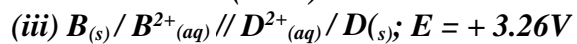
B (i) a. – D^{2+}

b. – D^{2+}

(ii) C

$E_{cell} = E_{ordn} - E_{ordn}$

$$= +0.34 - (-2.92) = +3.26V$$



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

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

$$= 13.43kg \quad P 1$$

$$= 13.43kg \quad P 1$$

28. a) Strip of copper metal dissolved forming blue solution. \checkmark

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

$$c) \text{ E.m.f of cell} = (0.80 - 0.34)V \sqrt{1/2}$$

$$= 0.46V \sqrt{1/2}$$

- 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



(iii) $Q = It = 4 \times 160 \times 60 \quad (1/2 \text{ mk})$
 $= 14400C$

$$2 \times 96500C = 2 \times 35.5 \quad (1/2mk)$$

$$14400C = \frac{14400 \times 2 \times 35.5}{2 \times 96600}$$

$$= 5.297g \quad (1/2mk)$$

30. a) the bulb light $\sqrt{1/2}$

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



31. $Q = it$

$$IF = 69500C$$

$$= 40 \times (5 \times 60)$$

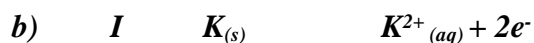
$$= 1200 C$$

$$\frac{2F}{96500} \times 206g \text{ of Pb}$$

$$F = \frac{1200 \times 1}{96500} \times 206$$

$$F = \frac{0.01243 \times 206}{2F}$$

$$= 0.01245 F \quad = 1.280g$$



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*

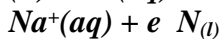
(ii) *Copper*



(iv) $E = 0.34 + 0.76$

$$= 1.0V$$

(b) (i) *Concentrated sodium chloride solution*



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

33. *Quantity of electricity = (40,000 X 60 X 60) Coulombus* \ddot{O} $\frac{1}{2}$ mark
3 x 96,500 Coulombus produce 27g of Al

$$\therefore \frac{40,000 \times 60 \times 60 \times 27}{3 \times 96,500 \times 1000} \text{ Kg} \quad \ddot{O} \frac{1}{2} \text{ mark}$$

$$= 13.43 \text{ Kg} \quad \ddot{O} \frac{1}{2} \text{ mark}$$

$$= 13.43 \text{ Kg} \quad \ddot{O} \frac{1}{2} \text{ mark}$$

Subtract $\frac{1}{2}$ mark if units missing or wrong

[Total 12 marks]

34. i) *Increased yield of NO/* \ddot{O} *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*

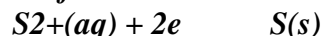
b) *T*

c) i) *T_(g) and S_(g)*

ii) *Half cell one*



Half cell two



iii) *T_(s) _____ T²⁺_(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*

$$= 2.5 \times (15 \times 60)$$

$$= 2250 \text{ C}$$

ii) *RAM = mass x valency x 96500*

$$= \frac{Q}{2250}$$

$$= \frac{0.74 \times 2 \times 96500}{2250}$$

$$= \frac{142820}{2250}$$

$$= 63.476$$

36. a) *R*

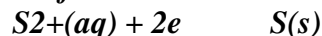
b) *T*

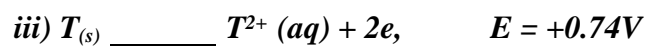
c) i) *T_(g) and S_(g)*

ii) *Half cell one*



Half cell two





iv) *From $T_{(s)}/ T^{2+}$ half cell to $S^{2+}/ S_{(s)}$ half cell through conducting wires*

d) i) $Q = It$
 $= 2.5 \times (15 \times 60)$
 $= 2250C$

$$\begin{aligned}
 \text{ii) RAM} &= \frac{\text{mass} \times \text{valency} \times 96500}{Q} \\
 &= \frac{0.74 \times 2 \times 96500}{220} \\
 &= \frac{142820}{2250} \\
 &= 63.476
 \end{aligned}$$

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) $Q = 0.5 \times 60 \times 64.3 = 1929\text{C}$

0.64g of Cu _____ 1929 C

∴ 63.5 of Cu

$\frac{63.5 \times 1929}{0.64}$ ✓ ½

0.64

= 191393 C ✓ ½

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

41. (a) The mass of substance liberated during electrolysis is directly proportional to the quantity of electricity passed

(b) Quantity of electricity = $2 \times 2 \times 36000 = 14400\text{c}$ (½mk)

Volume of gas evolved = $\frac{14400 \times 22.4}{2 \times 96500} = 1.671\text{dm}^3$ (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

44. (i) CaO is basic and P_4O_{10} is acidic P1

(ii) Let the ON of P be x

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

$\frac{4x}{4} = \frac{+20}{4}$

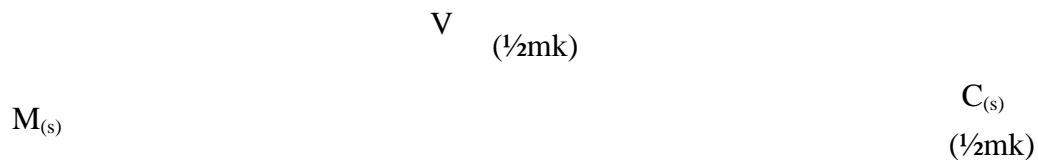
$x = +5$ P ½

(iii) Used as a fertilizer P1

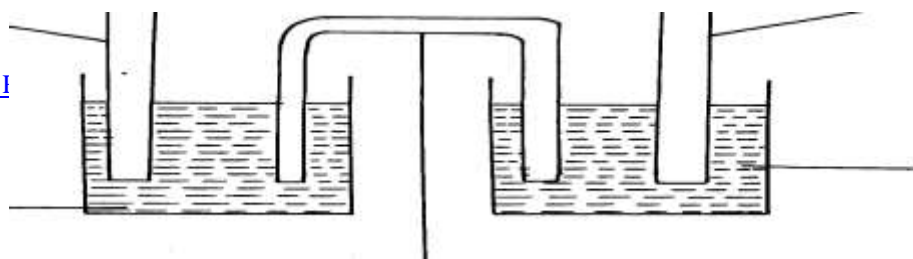
P1

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



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($\frac{1}{2}$ mk)

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

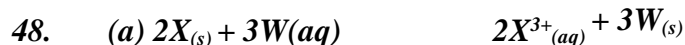
$M^{2+}_{(aq)}$

46. $+ 0.76 + 0.34 = 1.0 \text{Volts}$

($\frac{1}{2}$ mk)

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.*



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

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

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

P 1/2

P 1/2

Salt bridge

49. *Electrode - E₁ is the anode*

Dilute electrolyte – OH⁻ ions are discharged.



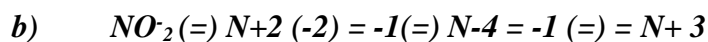
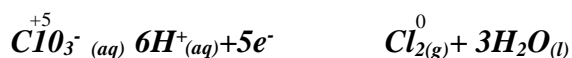
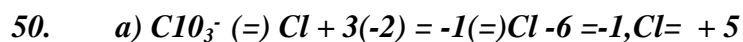
Oxygen gas is produced.

Discharge of hydroxyl ion increases the concentration of sodium chloride.

Chloride, Cl⁻ are then discharged.

Chloride, Cl⁻, are then discharged

Chloride gas is produce



51.

Half Cell	E°/V	E°/V using iron ref - electrode
$Al_{(s)} / Al^{3+}_{(aq)}$		- 1.22
$Zn_{(s)} / Zn^{2+}_{(aq)}$	- 0.76	+0.32
$Fe_{(s)} / Fe^{2+}_{(aq)}$		0.00
$Ni_{(s)} / Ni^{2+}_{(aq)}$	- 0.25	+ 0.19

52. $q = 1.5 \times 60 \times 15 = 1350$
 $J^{3+}_{(aq)} + 3e^- \rightarrow J_{(s)}$

$$\begin{aligned} 3F &= 3 \times 96500 && = 289\,500C \\ 289500C \text{ deposit} &&& = 52g \text{ of } J_{(s)} \\ = 1350 C \text{ deposit} &= 1350 \times 52 && \\ &289500 && = 0.2\,2425g \end{aligned}$$

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