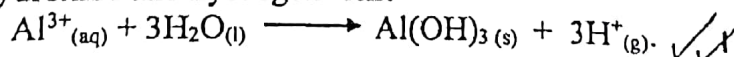1. a) From graph

Axes = 01 @ ½ with units if any
Scale = 01
Plot = 02
—————
04

(ii) The melting point generally decrease from sodium chloride to disulphur dichloride ✓

sodium chloride and Magnesium chloride have giant ionic structure in which the ions of opposite charge are held by strong ionic bonds; as ionic charge increases from sodium ion to magnesium ion, charge density ✓   05 increases in that order and so does the polarizing power; ionic character of the chlorides decreases sodium chloride and Magnesium chloride, ✓

Al_2Cl_6, $SiCl_4$, PCl_3 amd S_2Cl_2 have simple molecular structure with weak ✓ Van der Waal. Forces of attraction; as molecular mass increases, the Van der Wall's forces become stronger.

The melting point of disulphur dichloride is higher than that of phosphorous ✓ trichloride because it has a high molecular mass therefore forms stronger van-der-Waals forces of attraction
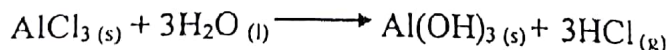
b) (i) Aluminum oxide is added to dilute hydrochloric acid ✓ as the mixture is being stirred to obtain a saturated solution; the solution is filtered and the filtrate is 03 evaporated up to crystallization point. The solution is cooled, the crystals are washed and dried ✓

(ii) Misty fumes ✓ and white solid. ✓ rej white-fumes   2½

$$2AlCl_3 . 6H_2O_{(s)} \longrightarrow 6HCl_{(g)} + 9H_2O_{(g)} + Al_2O_{3(s)}$$ ✓ –deny ½ for wrong w missing State symbol
– rej unbalanced equation.

(iii) Misty fumes. ✓
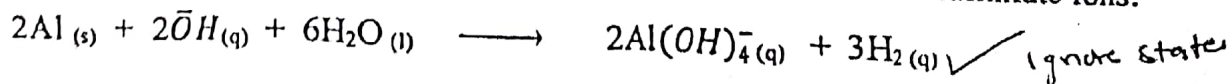Aluminum ion has high charge density undergoes hydrolysis to form aluminum hydroxide and hydrogen ions.

$$Al^{3+}_{(aq)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3H^+_{(g)}.$$ ✓✓   2½

Accept:

$$AlCl_{3(s)} + 3H_2O_{(l)} \longrightarrow Al(OH)_{3(s)} + 3HCl_{(g)}$$

c) Alkanoate ion from soap under goes hydrolysis to form a carboxylic acid and hydroxide ions.

$$RCOO^-_{(q)} + H_2O_{(l)} \rightleftharpoons RCOOH_{(q)} + \bar{O}H_{(q)}.$$ ✓ ignore states

Aluminum being amphoteric reacts with hydroxide ions to from aluminate ions. 3

$$2Al_{(s)} + 2\bar{O}H_{(q)} + 6H_2O_{(l)} \longrightarrow 2Al(OH)^-_{4(q)} + 3H_{2(q)}$$ ✓ ignore states

—————
20
—————

1

No2

(a)The ore is crushed and mixed with a frothing agent, air at high pressure passed through the mixture to agitate the mixture and the ore particles and the frothing agent rise and float while the impurities are wet by water and sink to the bottom. The ore in the froth is skimmed off and dilute nitric acid added, to break it down, it is filtered and dried.
The purified ore is is roasted in air to form zinc oxide and sulphur dioxide

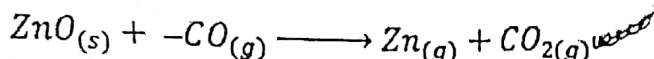$$ZnS_{(s)} + \tfrac{3}{2}O_{2(g)} \longrightarrow ZnO_{(s)} + SO_{2(g)}$$
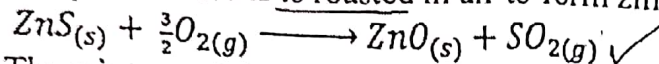
The mixture of zinc oxide, lime stone and coke are put in the blast furnace and hot air blown into the furnace
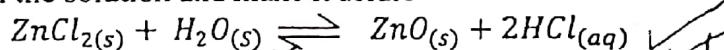Zinc oxide is reduced to zinc by carbon or carbon monoxide

$$ZnO_{(s)} + C_{(s)} \longrightarrow Zn_{(g)} + CO_{(g)}.$$

Or

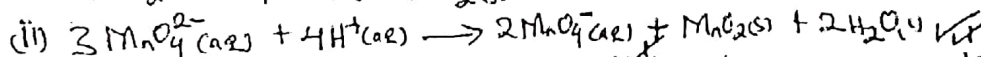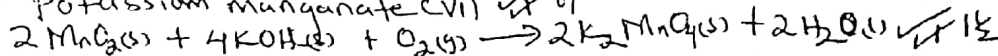$$ZnO_{(s)} + -CO_{(g)} \longrightarrow Zn_{(g)} + CO_{2(g)}$$
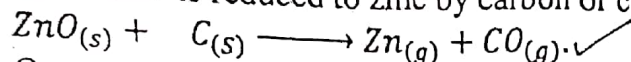
Zinc vapour distills off from the furnace, its cooled by spray of molten lead. It is the purified by redistillation

b(i) zinc is a d-block element because its outer most electrons are filled in the d-sub energy level. Zinc is not a transition element because both the tom and the zinc ion have completely filled 3d sub energy level.

(ii) zinc chloride undergoes hydrolysis to form zinc oxide and hydrogen chloride gas that dissolves in the solution and make it acidic

$$ZnCl_{2(s)} + H_2O_{(s)} \rightleftharpoons ZnO_{(s)} + 2HCl_{(aq)}$$

C.i) Potassium manganate(VI)
$$2MnO_{3(s)} + 4KOH_{(s)} + O_{2(g)} \longrightarrow 2K_2MnO_{4(s)} + 2H_2O_{(l)}$$

(ii) $$3MnO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)} \longrightarrow 2MnO_4^-{}_{(aq)} + MnO_{2(s)} + 2H_2O_{(l)}$$
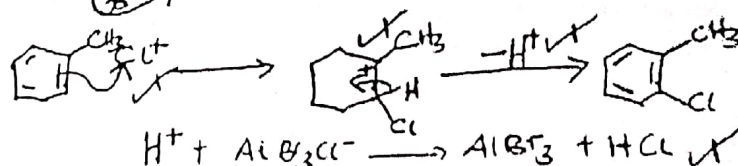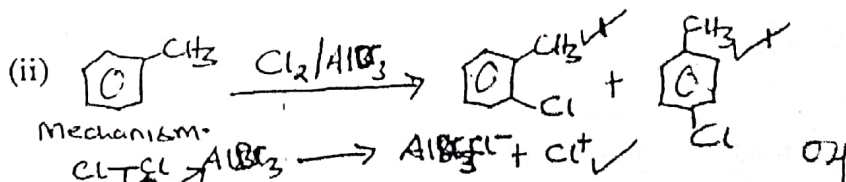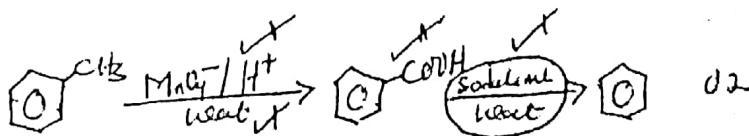
(iii) Sulphurdioxide is a reducing agent, It reduces Manganate(VII) ions to Manganese(II) ions and itself oxidised to a sulphate
$$2MnO_4^-{}_{(aq)} + 5SO_{2(g)} + 2H_2O_{(l)} \longrightarrow 2Mn^{2+}{}_{(aq)} + 5SO_4^{2-}{}_{(aq)} + 4H^+{}_{(aq)}$$
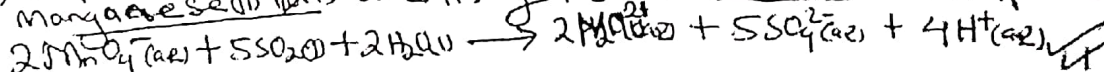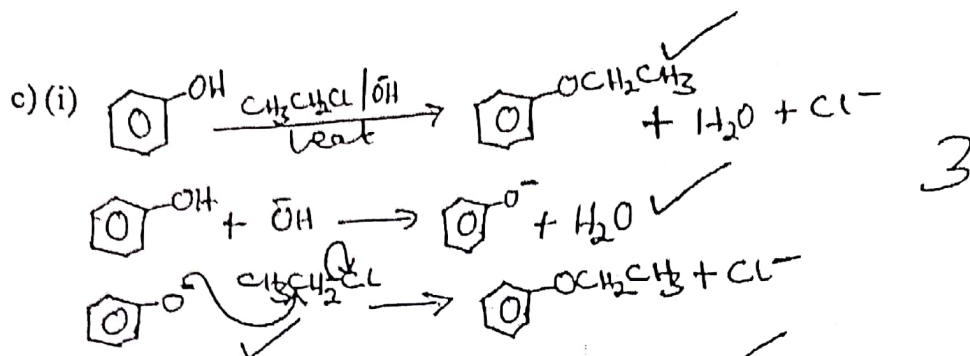
3. a) (i) Reaction of benzene with an electrophile in which the electrophile replaces one of the hydrogen atoms of benzene.

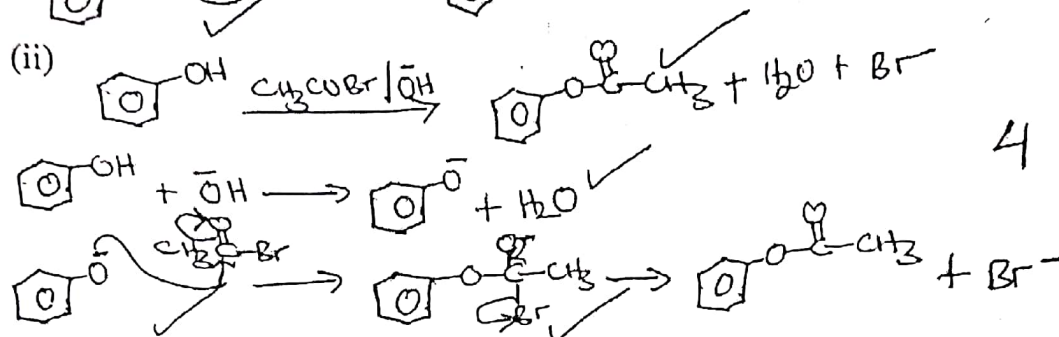(ii) Benzene has delocalized pie electron which mark it stable.

b) (i)

(ii)

Mechanism.
$$Cl-Cl + AlBr_3 \longrightarrow AlBr_3Cl^- + Cl^+$$

$$H^+ + AlBr_3Cl^- \longrightarrow AlBr_3 + HCl$$

2

c) (i)

$$C_6H_5OH \xrightarrow[\text{heat}]{CH_3CH_2Cl \,/\, \bar{O}H} C_6H_5OCH_2CH_3 + H_2O + Cl^-$$

$$C_6H_5OH + \bar{O}H \longrightarrow C_6H_5O^- + H_2O$$

$$C_6H_5O^- \xrightarrow{CH_3CH_2Cl} C_6H_5OCH_2CH_3 + Cl^-$$

3

(ii)

$$C_6H_5OH \xrightarrow{CH_3COBr \,/\, \bar{O}H} C_6H_5O-\overset{O}{\overset{\|}{C}}-CH_3 + H_2O + Br^-$$

$$C_6H_5OH + \bar{O}H \longrightarrow C_6H_5O^- + H_2O$$

4

$$C_6H_5O^- \xrightarrow{CH_3-\overset{O}{\overset{\|}{C}}-Br} C_6H_5-O-\overset{O}{\overset{|}{\underset{Br}{C}}}-CH_3 \longrightarrow C_6H_5-O-\overset{O}{\overset{\|}{C}}-CH_3 + Br^-$$

d) The lone pair of electron on the oxygen atom interacts with the declocalised pie electrons of benzene ring, the oxygen to hydrogen bond weakens and break to release hydrogen ions.
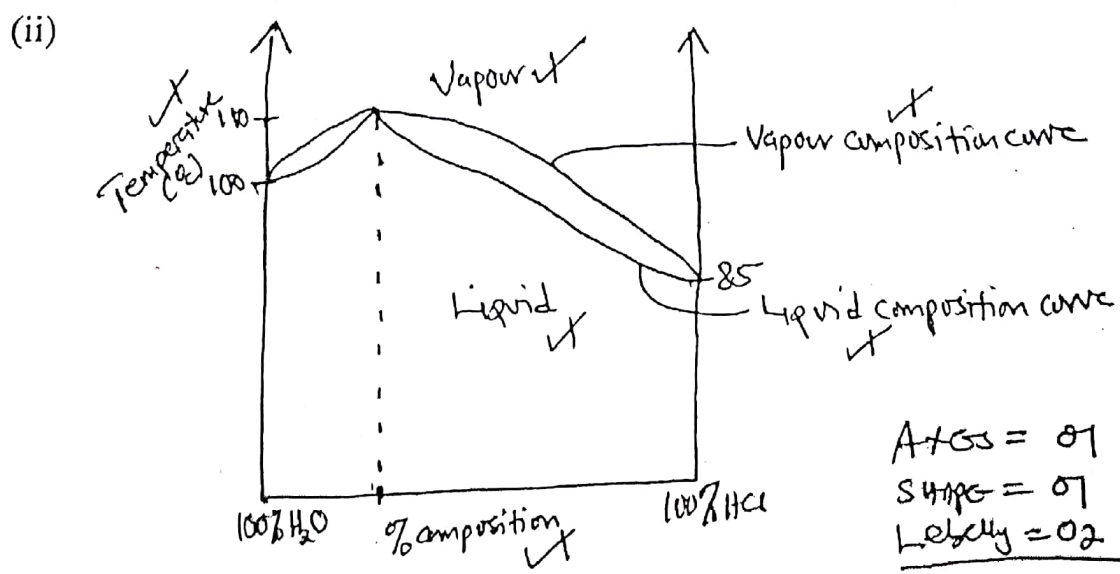

4

20
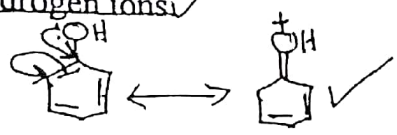
4. a) A solution that obeys Raoult's law formed with no change in total volume expected, no heat change occurs and adhesive forces are equal in magnitude to cohesive forces.

3

b) (i) A liquid mixture of fixed boiling point and composition that boils at constant temperature at given pressure to form vapour of the same composition of the liquid.

02

(ii)

Temperature (°C)
110
100
85

Vapour
Vapour composition curve
Liquid
Liquid composition curve

100% H₂O   % composition   100% HCl

A + Gs = 01
S type = 01
Lebelly = 02
_____
04

3

(iii) The mixture boils at a given temperature to form vapour which is <u>richer in water</u> ✓ than the origin liquid mixture, the vapour condenses <u>forming a liquid of the same</u> composition as the vapour.

Repeated heating and cooling of subsequent liquid mixtures <u>produces pure water</u> as 3 the distillate and <u>azeotropic mixture as the residue.</u> ✓

c) 1 cm³ of mixture contains 1.18g

1000cm³ of mixture contains $\dfrac{1.18 \times 1000}{1}$ = 1180g/l ✓

Mass of pure HCl = $\dfrac{20.5}{100}$ x 1180

= 241.9g/l ✓   2

RFm of HCl = 1 + 35.5 = 36.5

36.5g of HCl contain 1 mole

241.9g of HCl contain = $\dfrac{1}{36.5}$ x 241.9 = 6.62M ✓

d) (i) Partial pressure ~~of~~ = mole fraction x vapoour ✓

(P_z) = $\dfrac{1}{5}$ x 0.674 = 0.1348 atm ✓

P_y = $\dfrac{4}{5}$ x 0.453 = 1.348 atm ✓   4

P_{total} = $P_x + P_z$ ✓ ✓   20
= 0.1348 + 0.3624 = 0.4972 atm

(ii) Solution deviates ~~negative negatively~~ Positively ✓. This is because the vapour pressure of solution is ~~less~~ greater than that expected if the solution was ideal.   02

5. a) (i) Reagent : Brady's reagent |2,4-dinitrophenyl hydrazine solution
      Observation : Yellow/orange precipitate ✓.
      Accept : Ammoniacal silver intrate solution and heat
      Observation : Silver mirror.

   (ii) Reagent : Acidified potassium manganite (VII) solution ✓
      Observation : Puple solution turns colourless. ✓   2
      Accept : Bromine water.
      Observation : reddish brown solution turns colourless.

   (iii) Reagent : Potassium | sodium carbonate solution ✓ ~~Podium clarbonate solution~~
      Observation : bubbles of a coulourless gass. ✓

   (iv) Reagent : Phosphorus pentachloride ✓

4

Observation : misty fumes. ✓

Acept Sodium metal ⟶ Bubbles of a colourless gas

b) (i) Reagent : Fehling's solution and heat ✓

  observation : reddish brown precipitate with [benzene ring]—CH$_2$CHO

    : no observable change with [benzene ring]—CHO **3**

(ii) Reagent : Ammioniacal silver nitrate solution

  observation :

  $CH_3C\equiv CCH_3$ no observable change ✓ **3**

  $CH_3C\equiv CH$ white precipitate. ✓

  Accept : Ammioniacal copper(I) chloride solution

  observation :

  $CH_3C\equiv CCH_3$ no observable change

  $CH_3C\equiv CH$ red precipitate.

(iii) Reagent : Concentrated sulphuric acid and heat

  observation :   **3**

  CH_3COOH No observable change ✓

  $H_2C_2O_4$ Bubbles of a colourless gas. ✓

  Accept : Acidified potassium manganate (VII) solution and heat.

  observation :
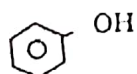
  CH_3COOH no observable change

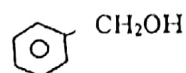 $H_2C_2O_4$: Purple solution turns colourless with bubbles of a colourless gas.

(iv) Reagent : Neutral iron (III) chloride solution ✓

  observation :

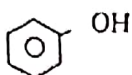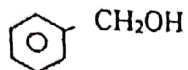 [benzene ring]—OH   Purple colouration ✓

  [benzene ring]—CH$_2$OH   no observable change ✓   **3**

            20

Accept: Ethanioc acid, concentrated pulphuric acid and heat.

Observation

|	
⬡—OH	Purple colouration
⬡—CH₂OH	Sweat fruity smell.

6. a) A saturated solution of the salt is prepared by adding excess of the salt to water in a bottle, the bottle is stopped, shaken and allowed to stand for some time at constant temperature. The conductivity of the saturated solution is measured using conductivity meter. The molar conductivity of the salt at infinite dilution is determined by getting the sum of the molar conductivities of the component ions at infinite dilution.is determined by getting the sum of the molar conductivities of the component ions at infinite dilution. The solubility of the salt is determined from the expression.

$\Lambda_0 = \dfrac{K_{salt}}{C}$ But $K_{salt} = K_{solution} - K_{water}$

C is the Solubility of the salt, Assumption: molar conductivity of solution is equal to molar conductivity at infinite dilution for sparingly soluble salts.

Equation.

$Ag_2C_2O_4(s) \rightleftharpoons Ag^+_{(aq)} + C_2O_4^{2-}_{(aq)}$
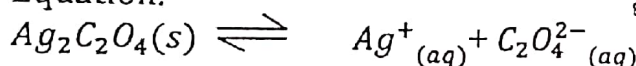
$[Ag^+] = 2S$, $[C_2O_4^{2-}] = S$

$Ksp = [Ag^+]^2[C_2O_4^{2-}]$

$= (2S)^2(S)$

$= 4S^3 mol^3 dm^{-9}$

Alternative:

A saturated solution of the salt is prepared by adding excess of the salt to water in a bottle to stand for some time at constant temperature. A known volume of the saturated solution is pipette, a small amount of dilute sulphuric acid is added and the mixture is warmed. The mixture is titrated with a standard solution of potassium manganate (VII) solution.

Manganate (VII) ions react with oxalate ions according to the equation.

$2MnO_4^-{}_{(aq)} + 5C_2O_4^-{}_{(aq)} + 16H^+{}_{(aq)} \longrightarrow 2Mn^{2+}_{(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}.$
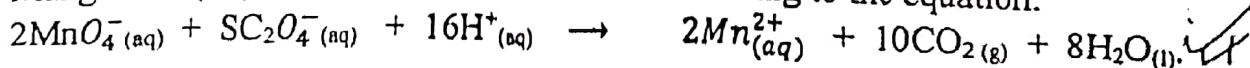
The results of the titration are used to calculate the concentration of oxalate ions

if $[C_2O_4^{2-}] = x$ $[Ag^+] = 2x$ Eqn: $Ag_2C_2O_4{}_{(s)} \rightleftharpoons Ag^+_{(aq)} + C_2O_4^{2-}_{(aq)}$

$Ksp = [Ag^+]^2 \cdot [C_2O_4^{2-}]$

$= (2x)^2 \times x$

$= 4x^3 mol^3 dm^{-9}$

6

(ii) K_{sp} = $[Ag^+]^2 [C_2O_4^{2-}]$ ✓

$[Ag^+]$ = $1.1 \times 10^{-4} \times 2$ ✓

$[C_2O_4^{2-}]$ = 1.1×10^{-4} ✓

K_{sp} = $(2 \times 1.0 \times 10^{-4})^2 \times 1.1 \times 10^{-4}$

= $5.324 \times 10^{-12} mol^3 dm^{-9}$ (7½)

Let S be solubility of $Ag_2C_2O_4$ in 0.01M $AgNO_3$

$[Ag^+]$ = $2S + 0.01$, $[C_2O_4^{2-}]$ = S ✓

5.324×10^{-12} = $(S + 0.01)^2 \times S$ ✓

Assumption $2S + 0.01 \simeq 0.01$ ✓

5.324×10^{-12} = $(0.01)^2 \times S$ ✓

S = $5.324 \times 10^{-8} moldm^{-3}$ ✓

b) (i) Silver ions in the saturated solution react with aqueous ammonia to form a soluble complex ion, equilibrium concentration of silver ions decreases, more silver chloride dissolves to replace the complexed silver ions. $Ag^+_{(aq)} + 2NH_{3(aq)} \longrightarrow Ag(NH_3)_2^+{(aq)}$ ✓

(ii) Barium ions in the saturated solution react with nitrate ions to form barium nitrate, the equilibrium concentration of barium ions decreases, more barium sulphate dissolves to replace the reacted barium ions.

$Ba^{2+}_{(aq)} + 2NO_3^-{(aq)} \longrightarrow Ba(NO_3)_{2(aq)}$ ✓ 3

20

7a

(i) Reduction potential of a half cell measured relative to the standard hydrogen electrode at 298k (25°c) and 1atom. ✓ 2

ii) Atomization energy. The lower the ionization energy, the higher the standard electrode potential because gaseous atoms and easily formed. ✓   04
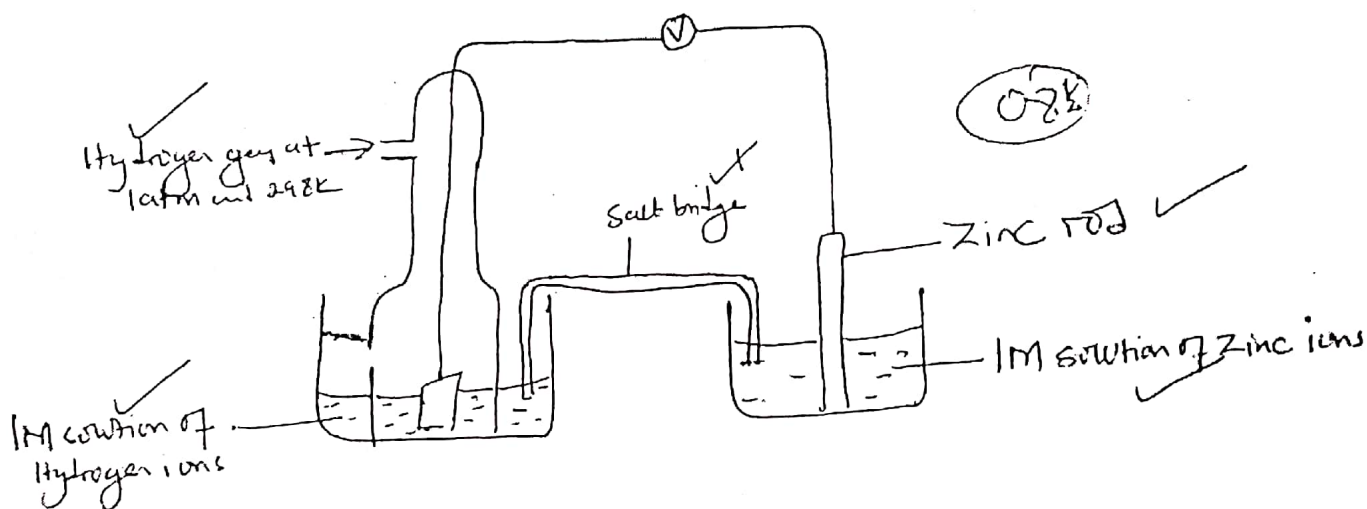
Ionization energy. The lower the ionization energy, the higher the standard electrode potential because gaseous ions are easily formed.   Accept any two

Hydration energy, the higher the hydration energy the higher the standard electrode potential because gaseous ions attract more water molecules

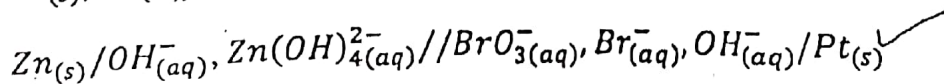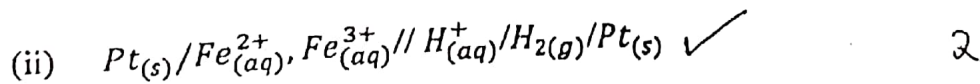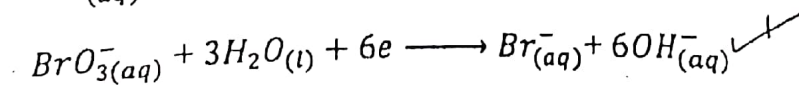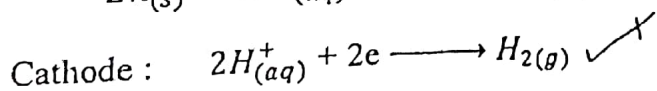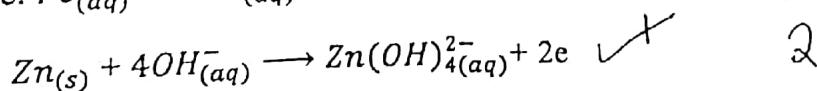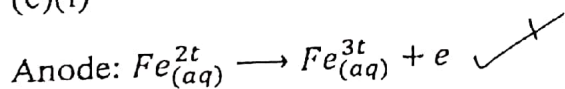b) The zinc rod is dipped in a one molar solution of its ions to make a zinc half-cell. The zinc half-cell on the right is connected to the standard hydrogen electrode on the left using a salt bridge to complete the internal circuit and connecting wire through a high resistance voltmeter to complete the external circuit

Hydrogen gas bubbled at 25°C over

The standard hydrogen electrode consists of platinized platinum dipped in a one molar solution of hydrogen ions at 298k

The e.m.f of the zinc half-cell is measured using the voltmeter since the electrode potential of the standard hydrogen electrode is taken as 0.00v, the reading of the voltmeter is the reduction potential of the zinc half-cell.

Hydrogen gas at 1atm and 298k

Salt bridge

Zinc rod

1M solution of Zinc ions

1M solution of Hydrogen ions

(c)(i)

Anode: $Fe^{2t}_{(aq)} \longrightarrow Fe^{3t}_{(aq)} + e$

$Zn_{(s)} + 4OH^-_{(aq)} \longrightarrow Zn(OH)^{2-}_{4(aq)} + 2e$ 2

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

$BrO^-_{3(aq)} + 3H_2O_{(l)} + 6e \longrightarrow Br^-_{(aq)} + 6OH^-_{(aq)}$

(ii) $Pt_{(s)}/Fe^{2+}_{(aq)}, Fe^{3+}_{(aq)} // H^+_{(aq)}/H_{2(g)}/Pt_{(s)}$ 2

$Zn_{(s)}/OH^-_{(aq)}, Zn(OH)^{2-}_{4(aq)} // BrO^-_{3(aq)}, Br^-_{(aq)}, OH^-_{(aq)}/Pt_{(s)}$

(iii) // salt bridge

/ Separation of species at the same electrode in different physical state 1½

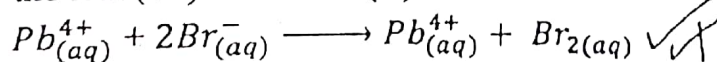, separation of species at the same electrode in different physical states

20

8

(a) Cations of group (II) elements have higher ionic charge (+2) and smaller ionic radius than the corresponding cations of group (I) elements. The charge density of cations of group (II) elements therefore higher than that of group (I) cations

(b) Zinc chloride undergoes hydrolysis in water to form zinc oxide and hydrogen chloride

$$ZnCl_{2(s)} + H_2O_{(s)} \rightleftharpoons ZnO_{(s)} + 2HCl_{(aq)}$$
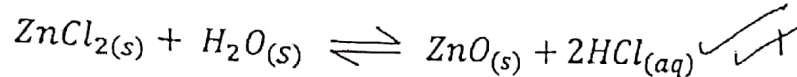
(c) Alkenes have a carbon to carbon double bond which is electron rich and donates electrons to the electrophiles while the carbonyl group is polar because oxygen is more electronegative than carbon, oxygen attracts the bonding electrons to attain a partial negative charge and carbon attains a partial positive charge. The carbon atom is center for nucleophilic attack

(d) Methanoic acid has a hydrogen atom attached to the carboxyl group, the hydrogen atom has no inductive effect, the oxygen–hydrogen bond is weakest
Ethanoic acid has methyl group attached to the carboxyl carbon, it exerts a positive inductive effect making the oxygen-hydrogen bond stronger. The oxygen-hydrogen bond in methanoic acid breaks easily to release hydrogen ions in solution than oxygen-hydrogen in Ethanoic acid.

(e) Bromide ions is stronger reducing agent than the chloride ion because the ionic radius of bromide ions is bigger than that of chloride ion. The bromide ion reduces the lead(IV) ion to lead(II) ions

$$Pb^{4+}_{(aq)} + 2Br^-_{(aq)} \longrightarrow Pb^{4+}_{(aq)} + Br_{2(aq)}$$

END