

MARKING GUIDE UACE PAPER 2 JJEB 2019

1(a) Hess' law

The heat change of a chemical reaction at a constant temperature and pressure is the same irrespective (independent) of the reaction route but will depend on the initial and final physical states of reactants and products of the reaction. (01 mark)

For reaction route also accept; Number of stages passed through/path taken

(b) (i) Hydration energy ;

This is the heat change that occurs when one mole of a gaseous ion is completely surrounded by water molecules.

Accept heat evolved since it's exothermic

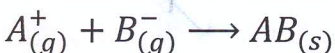


(02 mark)

Accept any cation or anion, rej equation with wrong states or without states

(ii) Lattice energy

The heat change that occurs (evolved) when one mole of an ionic crystal lattice is formed from its constituent gaseous ions

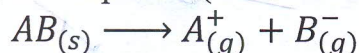


(02 mark)

Accept ionic compound for crystal lattice, rej equation with wrong states or without states

Or

The heat change that occurs (absorbed) when one mole of an ionic crystal lattice is decomposed (broken down) into its constituent gaseous ions



Accept any ionic compound

(c) Ionic charge

The higher the ionic charge the higher the lattice energy. This is due to a strong electrostatic force of attraction between the oppositely charge ions (1½ marks)

Ionic radius

The smaller the ionic radius, the higher the lattice energy because the ions of opposite charge will be will be closer to one another experiencing strong electrostatic force of attraction. (1½ marks)

Accept; vise verse

(d) (i) Heat change = mass of solution x S.H.C x Temperature change ($\Delta\theta$)

$$(4 + 50) \times 4.2 \times 8 = 1814.4\text{J}$$

This heat change is negative because heat is being given off hence increase in temperature = -1814.4J

$$\text{RFM of } \text{CuSO}_4 = 64 + 32 + (16 \times 4) = 160$$

4g of CuSO_4 dissolve in 50g of water to evolve -1814.4J

$$160\text{g of } \text{CuSO}_4 \text{ dissolve in 50g of water to evolve } \left(\frac{-1814.4 \times 160}{4} \right)$$

$$= -725676\text{Jmol}^{-1} \quad (03 \text{ marks})$$

(ii) Temperature change = $24.5 - 23.6 = 0.9^\circ\text{C}$ ✓
 Heat change = mass of solution \times S.H.C \times Temperature change ($\Delta\theta$)
 $(4 + 50) \times 4.2 \times 0.9 = 204.12\text{J}$ ✓

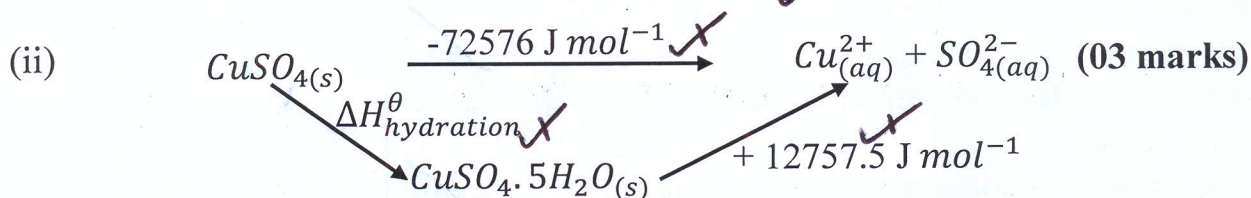
This heat change is positive because heat is being absorbed hence decrease in temperature = +204.12J ✓

RFM of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 64 + 32 + (16 \times 4) + (18 \times 5) = 250$ ✓
 4g of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ dissolve in 50g of water to evolve +204.12 J

250g of CuSO_4 dissolve in 50g of water to evolve $\left(\frac{+204.12 \times 250}{4} \right)$ ✓
 $= +12757.5 \text{ J mol}^{-1}$ ✓ (03 marks)

- (e) (i) Anhydrous copper (II) sulphate is more soluble than hydrated copper (II) sulphate because its enthalpy of solution is exothermic while that of hydrated copper (II) sulphate is endothermic. ✓

This is because the ions in hydrated copper (II) sulphate are already partially hydrated so that when dissolved in water, its lattice energy easily outweighs its enthalpy of hydration associated with any further hydration. (03 marks)



Deny $\frac{1}{2}$ mark for any missing or wrong state symbol

$$\begin{aligned}
 \Delta H_{\text{hydration}}^\theta &= -72576 - (+12757.5) \quad \checkmark \\
 &= -85333.5 \text{ J mol}^{-1} \quad \checkmark \quad \text{Accept } -85.3335 \text{ KJ J mol}^{-1}
 \end{aligned}$$

(TOTAL=20 marks)

2

(a)

- (i) Neutral iron (III) chloride solution. rej reagent without solution (01 mark)

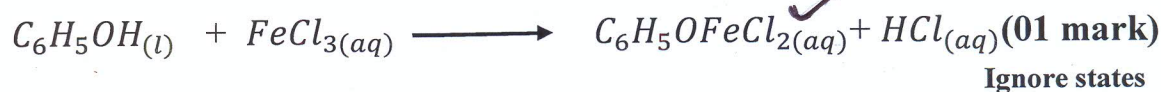
(ii) Observation:

Phenol : purple or violet colouration ✓ (01 mark)

Ethanol : no observable change ✓ (01 mark)

Rej observation if reagent is marked wrong

Equation :



(iii)

- Both react with phosphorous pentachloride to form respective chlorides
 - Both react with sodium metal to evolve hydrogen gas and the respective salt
 - Both react with acid chlorides to form esters
- Accept any corrects three and deduct 01 mark for any extra wrong

(03 marks)

(iv) Uses;

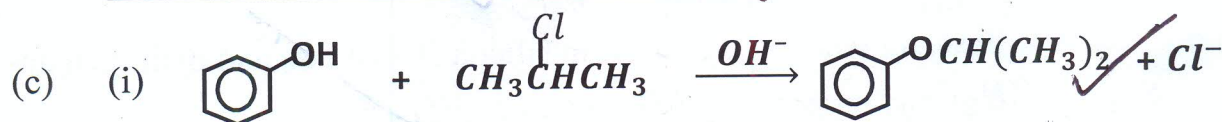
- Synthesis of Plastics like Bakelite
 - Manufacture of antiseptics, drugs like aspirin and some herbicides
 - Manufacture of non ionic detergents
- Accept any correct two and deduct 01 mark for any extra wrong

(02 marks)

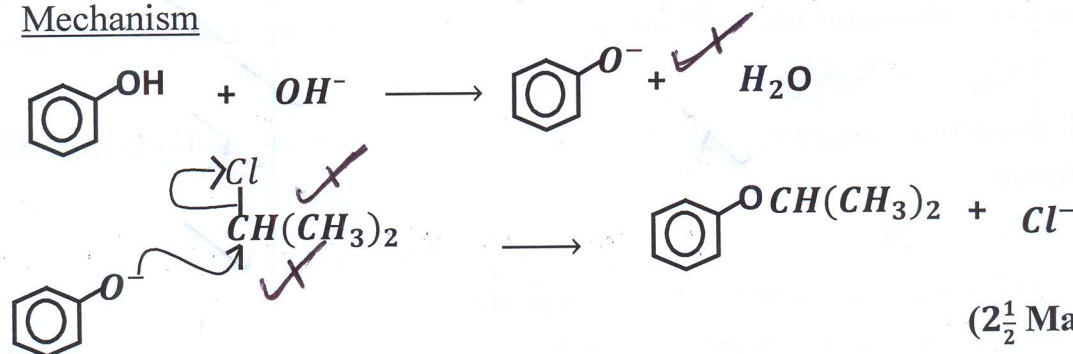
(b) Phenol is a weak acid while ethanol is neutral. This is because the lone pairs of electrons on the oxygen atom of the hydroxyl group in phenol interact with the delocalized π electrons in the benzene ring leading to formation of a partial double bond which shortens and strengthens the carbon-oxygen (C-O) bond but weakens the oxygen-hydrogen (O-H) bond that is easily broken when phenol is dissolved in water to release hydrogen ions responsible for the acidic nature.

Ethanol has no delocalized electrons instead has an alkyl group that has appositive inductive effect that pushes electrons towards the oxygen atom making the oxygen-hydrogen bond is stronger and doesn't easily break when dissolved in water to release hydrogen ions.

(04marks)



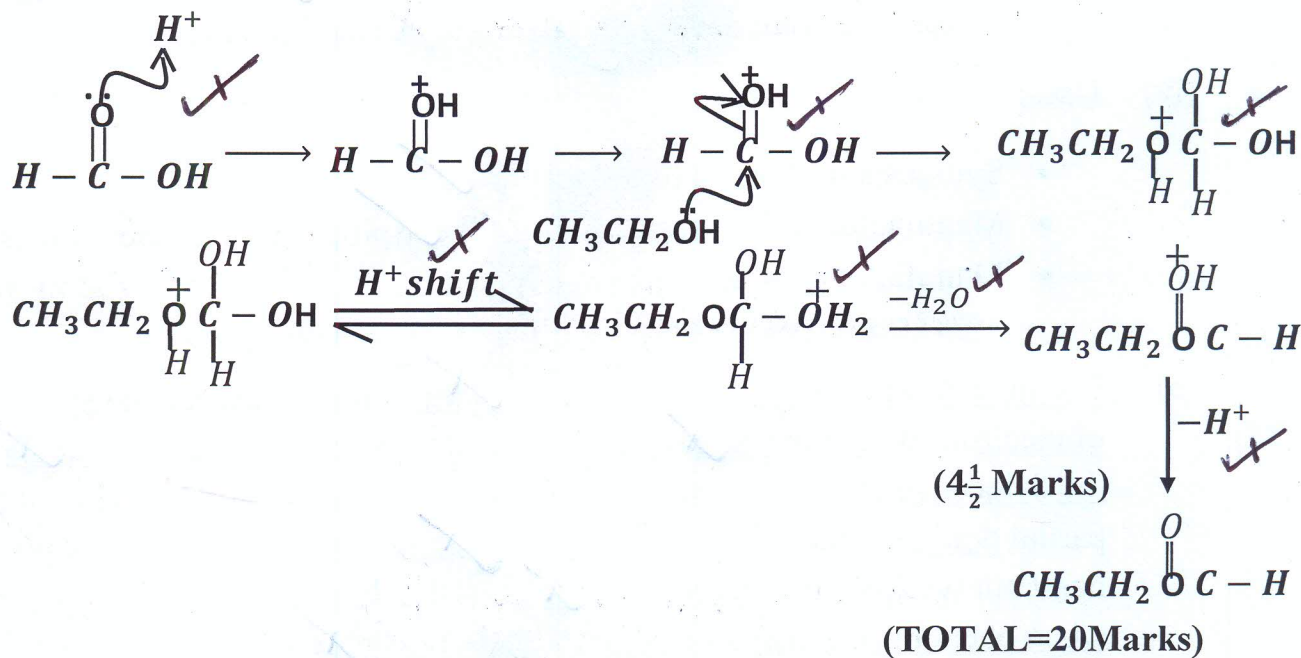
Mechanism



(2½ Marks)



Mechanism



- 3 (a) nS^2nP^2 ✓ (0½ Marks)
- (b)(i) Carbon reacts with steam when heated to form a mixture of carbon monoxide and hydrogen called water gas
- $$\text{C}_{(s)} + \text{H}_2\text{O}_{(g)} \longrightarrow \text{CO}_{(g)} + \text{H}_{2(g)} \quad \checkmark$$
- Silicon reacts with steam when heated to form silicon (IV) oxide and hydrogen gas
- $$\text{Si}_{(s)} + 2\text{H}_2\text{O}_{(g)} \longrightarrow \text{SiO}_{2(g)} + 2\text{H}_{2(g)} \quad \checkmark$$
- Tin reacts with steam when heated to form Tin (IV) oxide and hydrogen gas
- $$\text{Sn}_{(s)} + 2\text{H}_2\text{O}_{(g)} \longrightarrow \text{SnO}_{2(g)} + 2\text{H}_{2(g)} \quad \checkmark$$
- Lead reacts with soft cold water in presence of air (oxygen) to form lead (II) hydroxide.
- $$\text{Pb}_{(s)} + \text{H}_2\text{O}_{(l)} + \frac{1}{2}\text{O}_{2(g)} \longrightarrow \text{Pb}(\text{OH})_{2(s)} \quad \checkmark$$
- Award description with conditions and products
 - Rej equation for a wrong state of steam
- (6½ Marks)

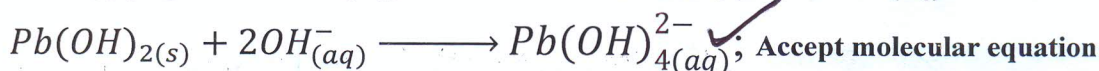
- (ii) Lead reacts with ethanoic acid in presence of air to form lead (II) ethanoate and water. Award description with conditions and products



- Deny $0\frac{1}{2}$ mark for equation with missing or any wrong state

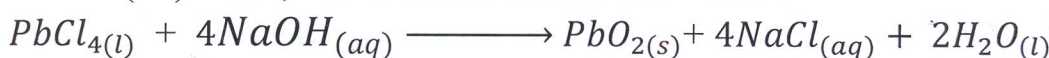
(02Marks)

- (iii) Lead (II) chloride reacts with dilute sodium hydroxide to form sparingly soluble lead (II) hydroxide and sodium chloride. The hydroxide formed reacts with excess sodium hydroxide to form a soluble complex



Accept molecular equation

Lead (IV) chloride reacts with dilute sodium hydroxide to form a brown solid of lead (IV) oxide, and sodium chloride and water



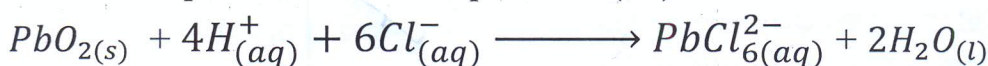
- Award description with products
- Ignore states for the equations

(4 $\frac{1}{2}$ Marks)

- (iv) Lead (IV) oxide reacts with cold concentrated hydrochloric acid to form a yellow liquid of lead (IV) chloride and water



Lead (IV) oxide reacts with excess cold concentrated hydrochloric acid to form a complex of hexachloroplumbate(IV) ion and water



Lead (IV) oxide reacts with warm concentrated hydrochloric acid to form lead (II) chloride, chlorine gas and water



- Award description with products
- Ignore states for the equations

(4 $\frac{1}{2}$ Marks)

- (v) Silicon reacts with concentrated hydrofluoric acid only to form hexafluorosilicic acid and hydrogen gas



- Award description with conditions and products
- Deny $0\frac{1}{2}$ mark for equation with missing or any wrong state

(02Marks)

(TOTAL=20 marks)

- 4(a) Pure Chloroform molecules and pure propanone molecules interact via van-der Waals forces of attraction but both are polar compounds. The polarity in propanone is due to difference in electronegativity between carbon and the oxygen atom making the C=O bond polarized while the polarity in chloroform is due to a high electronegativity of the three chlorine atoms which creates a partial positive charge to the hydrogen atom. When mixed Intermolecular hydrogen bonding between the chloroform and propanone are formed;



This is a stronger intermolecular attraction formed with evolution of heat and contraction of volume.

(04Marks)

- (b) Methanoic acid has a hydrogen atom attached to the carboxyl group ($H-\overset{O}{\parallel}C-OH$). This makes methanoic acid to have both carboxylic acid and aldehyde properties, therefore can be oxidized by ammoniacal silver nitrate solution to carbon dioxide and silver ions reduced to silver metal



Accept any other correct equation

In ethanoic acid ($CH_3-\overset{O}{\parallel}C-OH$), there is a methyl group attached to the carboxyl group making ethanoic acid to have only carboxylic acid properties and is resistant to oxidation hence doesn't react with ammoniacal silver nitrate solution. (04Marks)

- (c) The fluorine atom in hydrofluoric acid is very electronegative due to a very small atomic radius forming a very strong bond with the hydrogen atom, therefore when hydrofluoric acid is dissolved in water doesn't readily release the hydrogen ion making it a weak acid



However in high concentration, the fluoride ion released reacts with the hydrofluoric acid molecules to form a hydrogen difluoride ion (HF_2^-).



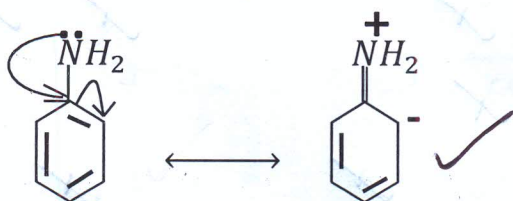
This reduces the concentration of fluoride ions at equilibrium, therefore more of the hydrogen fluoride molecules dissolve releasing fluoride ions and more of the hydrogen ions which shifts the equilibrium to the right.

(05Marks)

- (d) Benzene and water molecules do not interact therefore form an immiscible mixture in which each of the components contributes its own vapour pressure independent of the other such that the total vapour pressure above the mixture is the sum of the vapour pressure contributed by benzene and water molecules which will be too high compared to the vapour pressure of either components. The mixture will boil at a lower temperature because less heat is needed to generate enough molecules that can cause the vapour pressure of the mixture to be equal to atmospheric pressure.

(03Marks)

- (e) The strength of a base depends on the ease of donation of electrons. In phenyl amine, the lone pairs of electrons on the nitrogen atom interact with the delocalized pie bonding system of the Benzene ring which makes them less available for donation

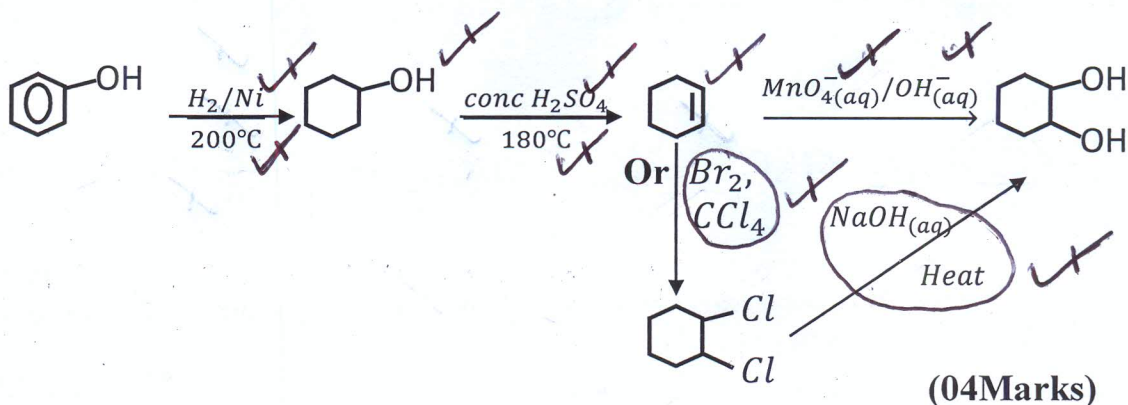


In the ethyl amine the methyl group that has a positive inductive effect tends to push electrons towards the nitrogen atom which increase electron density on the nitrogen atom and makes the lone pairs of electrons more available for donation. (04Marks)

(TOTAL=20 marks)

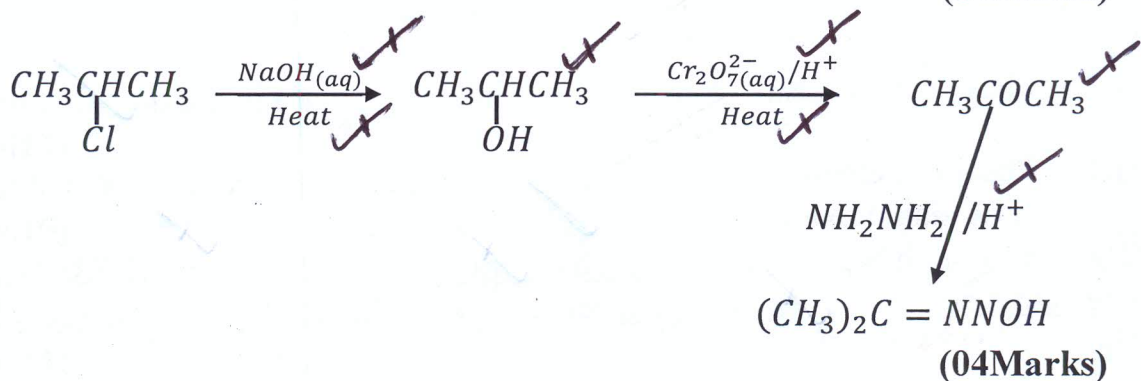
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(a)

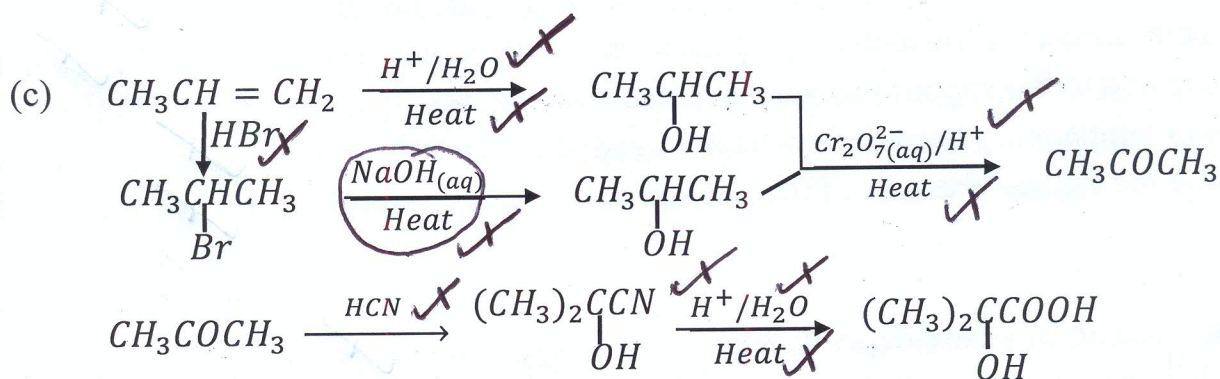


(04Marks)

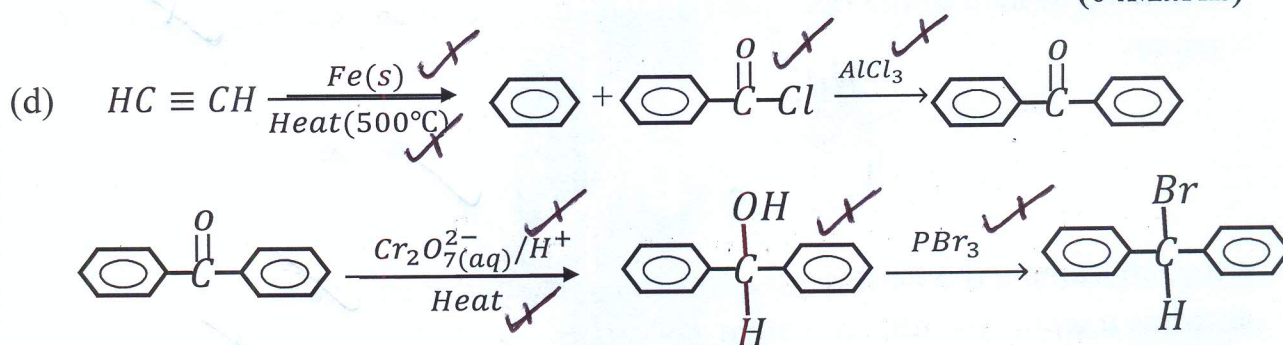
(b)



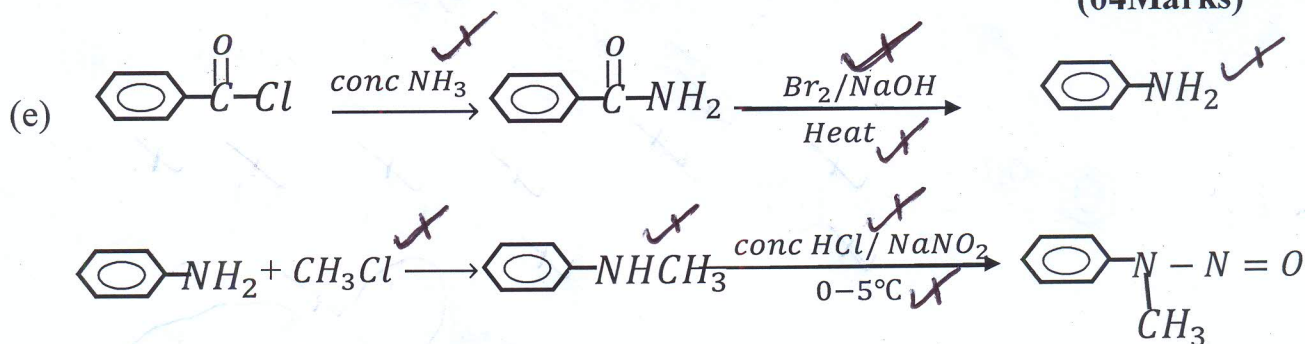
(04Marks)



(04Marks)



(04Marks)



(04Marks)

- Stop marking once; reagent is wrong, condition is wrong, symbol or formulae is wrong, reaction is wrong

(TOTAL=20 marks)

- 6(a) (i) These are elements whose outer most electrons are in the d-orbital or subshell. (01Marks)
- (ii) This is an element with a partially filled d-orbital in its atom and at least one of its stable oxidation state. (01Marks)
- (b) The zinc atom has a completely filled d-orbital ($1s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$) and forms one stable zinc ion in +2 oxidation state in which the d-orbital is also completely filled up ($1s^2 2p^6 3s^2 3p^6 3d^{10}$) ($1\frac{1}{2}$ Marks)

(c) (i)

Both zinc and magnesium react with oxygen when heated to form zinc oxide and magnesium oxide respectively (2½ Marks)



Both zinc and magnesium react with steam when heated to form the respective oxide and hydrogen gas (2½ Marks)



Both zinc and magnesium react with dilute non oxidizing acids like hydrochloric acid and sulphuric acid to form the respective salt and hydrogen gas (2½ Marks)



Both zinc and magnesium react with chlorine when heated to form chlorides



Both zinc and magnesium react with nitrogen when heated to form Nitrides



Accept any correct three

(7½ Marks)

Award (0½ mark) for a correct reactants, and product

Award (01 mark) for each of the equation and ignore states

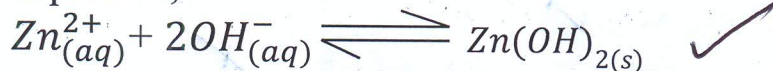
Reject unbalanced equation

(ii) Observation;

White precipitate soluble forming a colourless solution

(01 Marks)

Equation;

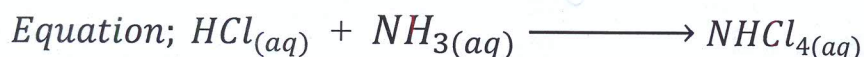


(02 Marks)



(d) **Concentration of ammonia in organic layer**

$$\begin{aligned} \text{Moles of HCl that neutralised organic layer} &= \left(\frac{12.5 \times 0.025}{1000} \right) \\ &= 3.125 \times 10^{-4} \quad \checkmark \end{aligned}$$



1 mole of HCl react with 1 mole of NH₃

$$\begin{aligned}
 3.125 \times 10^{-4} \text{ will react with} &= \left(\frac{1 \times 3.125 \times 10^{-4}}{1} \right) \\
 &= 3.125 \times 10^{-4} \text{ moles} \\
 25 \text{ cm}^3 \text{ of the organic layer contains} &3.125 \times 10^{-4} \text{ moles} \\
 1000 \text{ cm}^3 \text{ of the organic layer contains} &\left(\frac{3.125 \times 10^{-4} \times 1000}{25} \right) \\
 &= 0.0125 \text{ M} \quad \checkmark
 \end{aligned}$$

Total Concentration of ammonia in aqueous layer

$$\begin{aligned}
 \text{Moles of HCl that neutralised aqueous layer} &= \left(\frac{20 \times 0.25}{1000} \right) \\
 &= 5 \times 10^{-3} \quad \checkmark
 \end{aligned}$$

1 mole of HCl react with 1 mole of NH_3

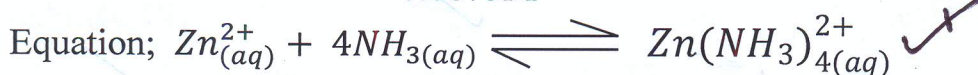
$$\begin{aligned}
 5 \times 10^{-3} \text{ will react with} &= \left(\frac{1 \times 5 \times 10^{-3}}{1} \right) \\
 &= 5 \times 10^{-3} \text{ moles} \\
 12.5 \text{ cm}^3 \text{ of the organic layer contains} &5 \times 10^{-3} \text{ moles} \\
 1000 \text{ cm}^3 \text{ of the organic layer contains} &\left(\frac{5 \times 10^{-3} \times 1000}{12.5} \right) \\
 &= 0.4 \text{ M} \quad \checkmark
 \end{aligned}$$

Concentration of free ammonia in the aqueous layer

$$\begin{aligned}
 \text{KD} &= \frac{[\text{NH}_3]_{\text{organic}}}{[\text{NH}_3]_{\text{free}}} \\
 [\text{NH}_3]_{\text{free}} &= \frac{0.0125}{0.04} = 0.3125 \text{ M} \quad \checkmark
 \end{aligned}$$

Concentration of complexed ammonia in the organic layer

$$\begin{aligned}
 [\text{NH}_3]_{\text{complexed}} &= \text{Total}[\text{NH}_3]_{\text{aqueous}} - [\text{NH}_3]_{\text{free}} \\
 &= 0.4 - 0.3125 \\
 &= 0.0875 \text{ M} \quad \checkmark
 \end{aligned}$$



4 moles of ammonia are complexed by 1 mole of zinc ions

$$0.0875 \text{ M of ammonia will be complexed by } \left(\frac{0.0875 \times 1}{4} \right) = 0.0219 \quad \checkmark$$

$$\begin{aligned}
 \text{Mass of zinc in the ore} &= \text{moles} \times \text{relative atomic mass} \\
 &= 0.0219 \times 65 \\
 &= 1.423 \text{ g l}^{-1} \quad \checkmark
 \end{aligned}$$

500 cm³ of a solution contained 3.0 g of the ore

$$1000 \text{ cm}^3 \text{ of the solution would contain } \left(\frac{3 \times 1000}{500} \right) = 6 \text{ g}$$

(05 Marks)

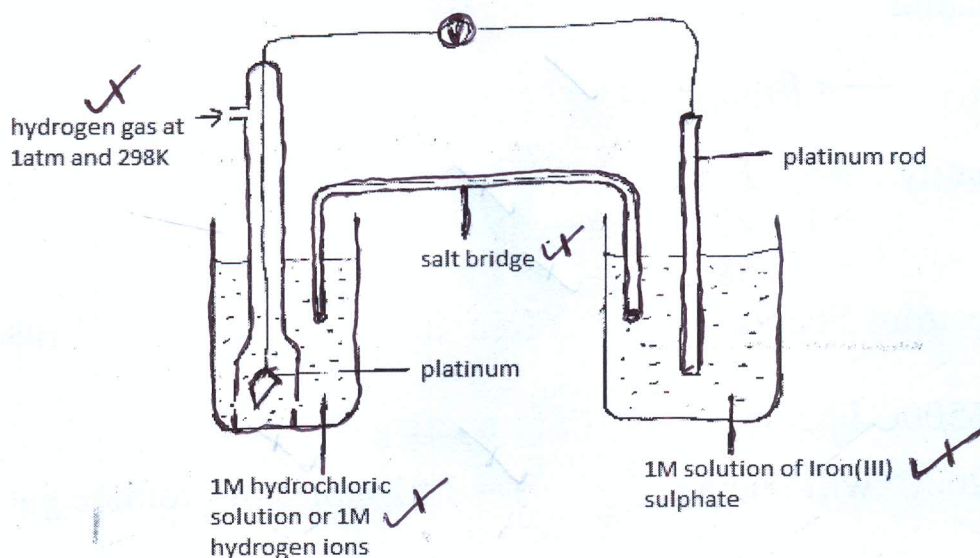
$$\% \text{ of zinc in the ore} = \left(\frac{1.423 \times 100}{6} \right) = 23.72 \% \quad \checkmark$$

(Assumption; all the zinc in the ore is complexed by excess ammonia)

- (e) Solvent extraction, qualitative analysis to distinguish bromide and iodide ions and chromatography (01 mark)

(TOTAL=20 marks)

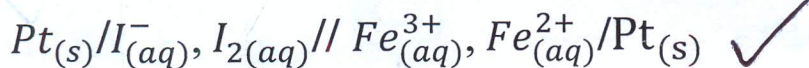
- 7 (i) This is the potential difference or reduction potential established when an electrode is dipped into a one molar solution of its ions and measured relative to the standard hydrogen electrode at standard temperature and pressure. (01Marks)
- (ii) A platinum rod is dipped in an aqueous solution of one molar Iron(III) sulphate to form a half cell. The half cell is then connected to the standard hydrogen electrode (S.H.E) half cell externally using a connecting wire via a high resistance voltmeter and internally using a salt bridge. The reading of the voltmeter gives the value of standard electrode potential Iron (III) sulphate since the S.H.E has an electrode potential of 0.00V.



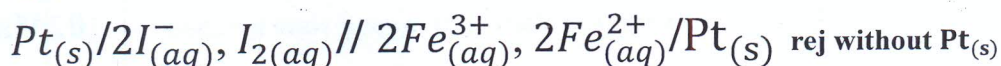
(06Marks)

- (ii) To measure the electrode potential absolutely would require connecting a high resistance voltmeter to the platinum rod dipped in one molar Iron(III) sulphate solution and to the solution. However when dipped in the solution, the connecting wire would develop its own electrode potential such that the voltmeter reading is for the combined two electrodes. (02Marks)

- (c) (i) cell convention



Or



rej without $Pt_{(s)}$

Equation



Deny $\frac{1}{2}$ for wrong or missing state symbols on equation (2 $\frac{1}{2}$ Marks)

(ii)

$$E_{cell} = E_{Right} - E_{left}$$

$$(+0.76) - (+0.54)$$

$$= +0.22V$$

rej without positive sign

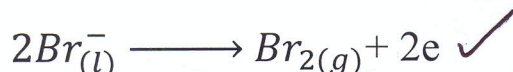
(1 $\frac{1}{2}$ Marks)

(iii) the reaction is feasible because the E.m.f of the cell is positive

Rej if E_{cell} is marked wrong

(01 Mark)

(d) (i) Equation



$$\text{Quantity} = It$$

$$= 40.5 \times 4 \times 60 \times 60$$

$$= 583200C$$

2 electrons liberate 1 mole of bromine gas

(03Marks)

2x96500C liberate 1 mole of bromine gas

$$583200C \text{ will liberate } \frac{583200}{2 \times 96500} = 3.02 \text{ moles of bromine gas}$$

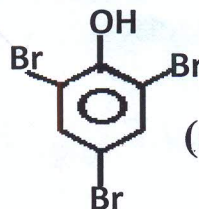
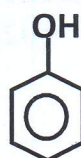
$$(ii) \text{ RFM of } C_6H_5OH = (6 \times 12) + (1 \times 6) + (16 \times 1)$$

$$= 94$$

$$\text{Moles of } C_6H_5OH = \frac{94.0}{94} = 1 \text{ mole}$$

(01Mark)

(d) Observation; white precipitate



deny $\frac{1}{2}$ for missing or wrong state symbols

(02Marks)

(TOTAL=20 marks)

8(a) (i)

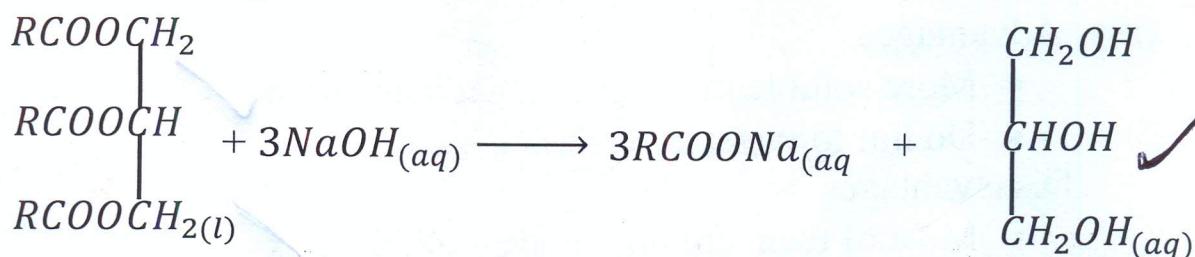
Oils	Fats
<ul style="list-style-type: none"> Liquid at room temperature ✓ 	<ul style="list-style-type: none"> Solids at room temperature ✓
<ul style="list-style-type: none"> Contains mainly unsaturated fatty acid 	<ul style="list-style-type: none"> Contains mainly saturated fatty acid

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(ii) Ground nuts seeds, simsim seeds, sunflower seeds, cotton seed e.t.c
Accept any one correct (01Mark)

(b) (i) Soap is a sodium or potassium salt of long chained carboxylic acids.
Rej without seed (01Mark)
(ii) Sodium stearate (sodium octadecanoate) ✓ (01Mark)

(c) (i) The oil is mixed with concentrated sodium or potassium hydroxide solution and the mixture is strongly heated to form a saturated solution (until frothing stops). Concentrated sodium chloride solution is added to the saturated solution to precipitate out soap a process called salting out soap. ✓
The soap is filtered off, washed with clean water and left to dry. ✓



Ignore states on the equation (04Marks)

(ii) R.F.M of the oil $\begin{array}{c} \text{C}_{15}\text{H}_{31}\text{COOCH}_2 \\ | \\ \text{C}_{15}\text{H}_{31}\text{COOCH} \\ | \\ \text{C}_{15}\text{H}_{31}\text{COOCH}_2 \end{array}$

$$(17 \times 3 \times 12) + (98 \times 1) + (16 \times 6) = 806 \quad \checkmark$$

$$\text{Moles of the oil that reacted} = \frac{9.5}{806} = 0.011787 \quad \checkmark$$

1 mole of the oil forms 3 moles of the soap

$$0.011787 \text{ moles of the oil will form } (0.011787 \times 3) = 0.03536 \quad \checkmark$$

$$\text{R.F.M of soap } C_{15}H_{31}COONa = (16 \times 12) + (31 \times 1) + (16 \times 2) + (23 \times 1) \\ = 278$$

$$\text{Mass of soap formed} = 287 \times 0.3536 \\ = 98.3\text{g}$$

(03Marks)

(iii) used to make animal feeds

Used to make fertilizers

(02 Marks)

(d) (i) Soap and detergents dissolve in water and lower the surface tension of water to allow water spread and wet more effectively. The hydrophobic part of soap attach to the dirt particle while the hydrophilic part gets attached to the water, this creates tension such that on agitation the dirt is slowly released from the cloth into water to form tiny globules that can be poured away. (03Marks)

(ii) Soap is a sodium salt of a long chain carboxylic acid ($RCOONa$) while detergents are sodium salts of alkyl benzene sulphonic acid or alkylsulphonic acid ($R - \text{C}_6\text{H}_4 - SO_3Na$) or $R - SO_3Na$) (02Marks)

(iii) Advantages

- More soluble in water than ordinary soap
- Do not form scum with hard water

Disadvantages

- Most of them are non biodegradable
- Encourage growth of algae if washed in water bodies (eutrophication)

- Attacks skin. award any one correct for each

(02Marks)

(TOTAL=20 marks)

END