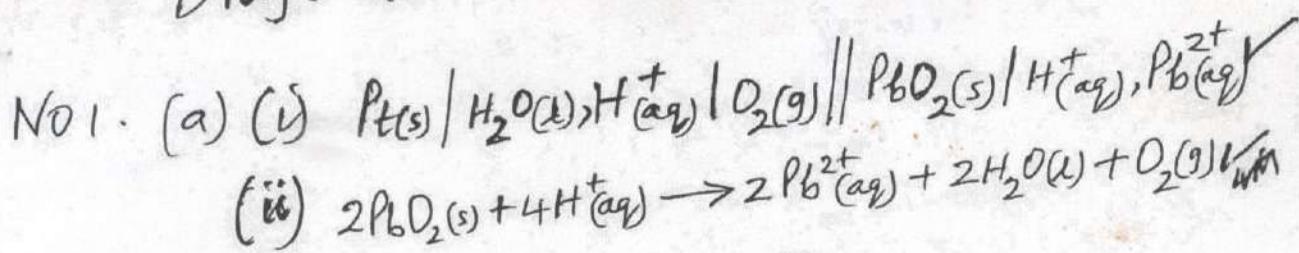


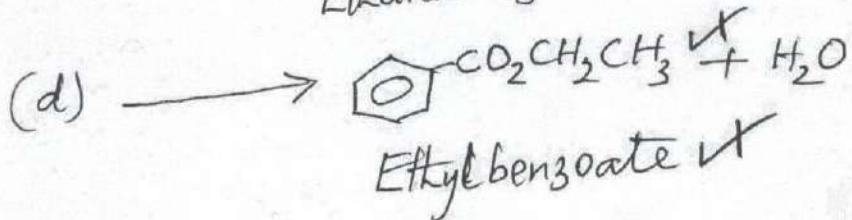
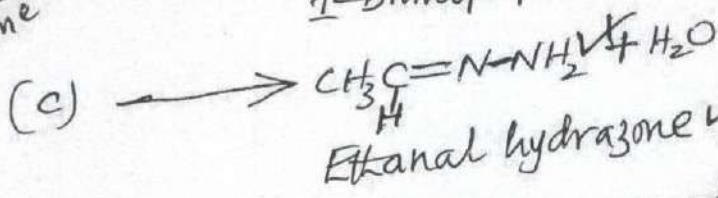
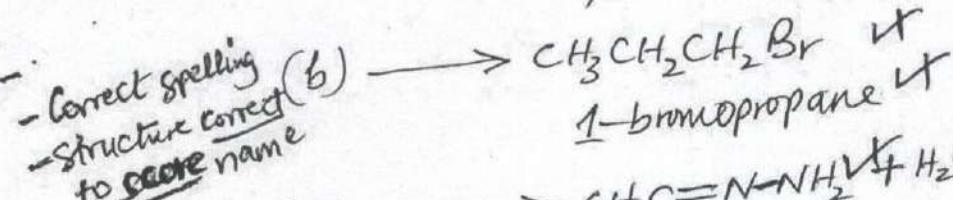
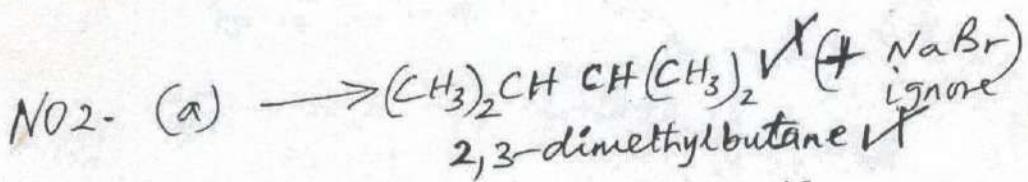
Draft Guide CHEMISTRY PS25 | 1



(b) (i) Emf of the cell = $E_r - E_L$
 $= 1.46 - 1.23 \text{ V}$
 $= 0.23 \text{ V}$ (both +ve and -ve must be indicated)

(ii) Feasible ✓
Positive ✓ since emf of the cell is

Q4



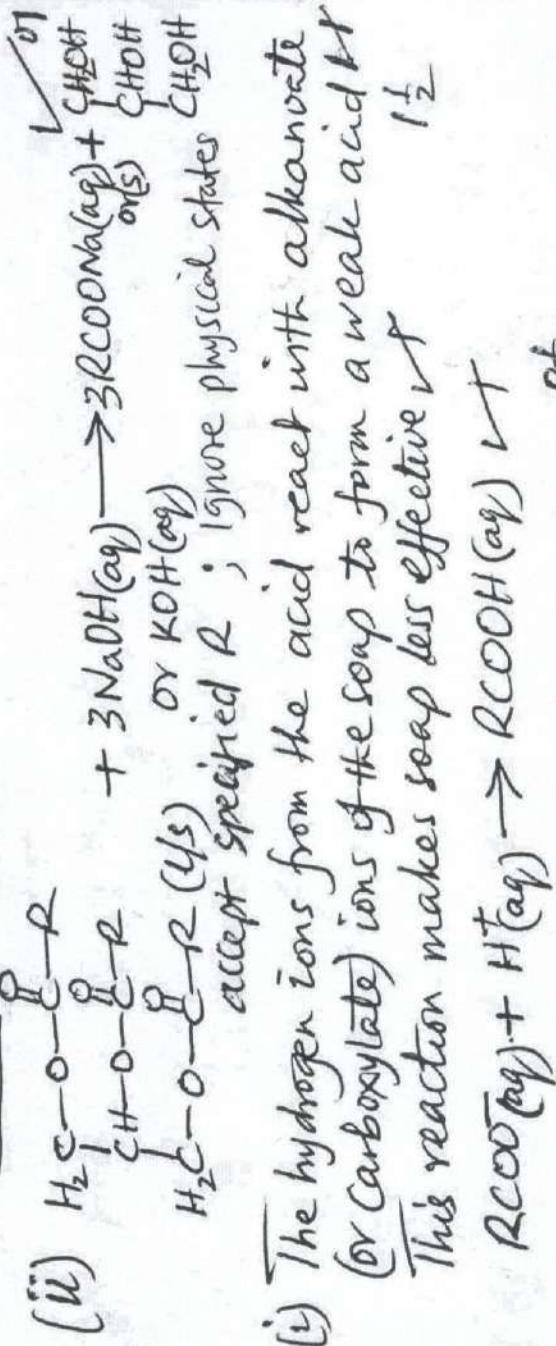
Q4

NO 3 (a) (i) A positively charged or negatively charged ion in which an atom or group of atoms with a negative charge or lone pair of electrons form coordinate/dative bonds with the central metal ion

- (ii) Availability of empty orbitals of suitable (or low) energy. If charge on the cation is }
— charge on the cation is }
— radius of the cation

(b) Hexacyanoferrate(III) ion ✓
Tetraamminecopper(II) ion ✓
(C) (i) bubbles of a colourless gas and brown solid
 $2Fe^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow 2Fe(OH)_3(s) + 3CO_2(g)$
(ii) $2Fe^{3+}(aq) + 3H_2O(l) \rightarrow 2Fe(OH)_3(s) + 3H_2O(l)$
or $2Fe^{3+}(aq) + 3CO_3^{2-}(aq) \rightarrow 2Fe(OH)_3(s) + 3CO_2(g)$

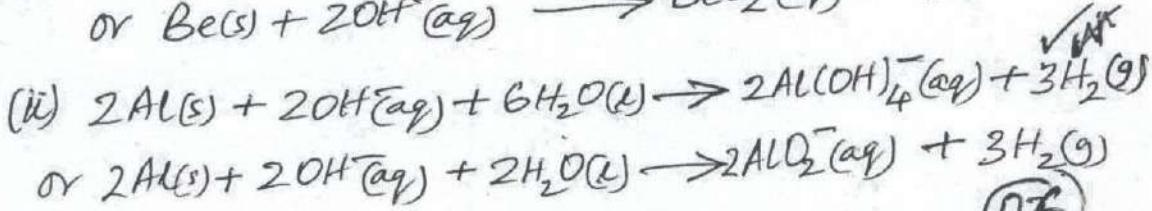
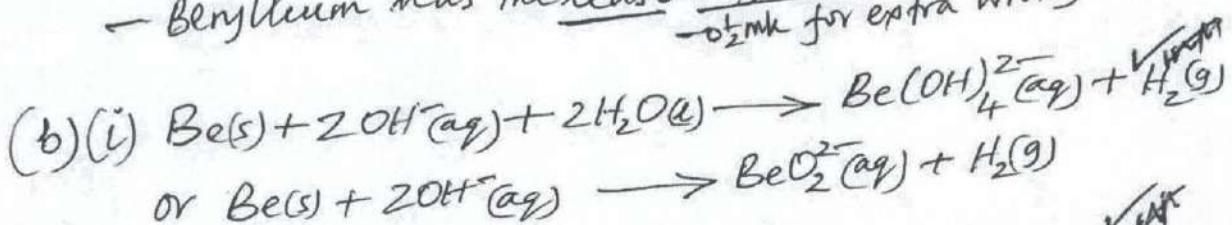
4. (a) (i) The oil/fat is heated & boiled with excess concentrated sodium hydroxide solution while stirring until the oil/fat completely dissolves. 2½
 The solution is cooled and concentrated sodium chloride solution (brine) is added to precipitate the soap which floats and is skinned off/removed, washed and dried.



- (ii) - Doesn't cause water pollution & it's biodegradable
 - cheaper
 - reject cheap

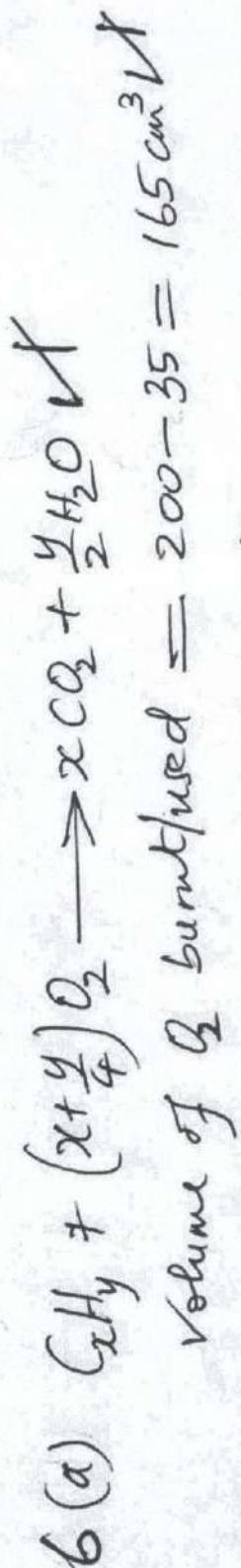
CH_3OH
 5½

- 5(a) (i) - Both elements are made passive by concentrated nitric acid ✓
 - Their oxides/hydroxides are amphoteric ✓
 - Their carbides hydrolyse in water to give methane and corresponding hydroxide ✓
 - Their chlorides are covalent polymeric solids when anhydrous.
 - Their chlorides exist as dimers in vapour phase
-0.1mk for extra wrong
- (ii) - Forms a cation with the highest charge density (or polarising power). ✓
 - Beryllium atom has the smallest atomic radius (or is the most electronegative) ✓
 - Beryllium has the least negative value of SEP
-0.2mk for extra wrong



Allow other correct alternative equations including molecular equations

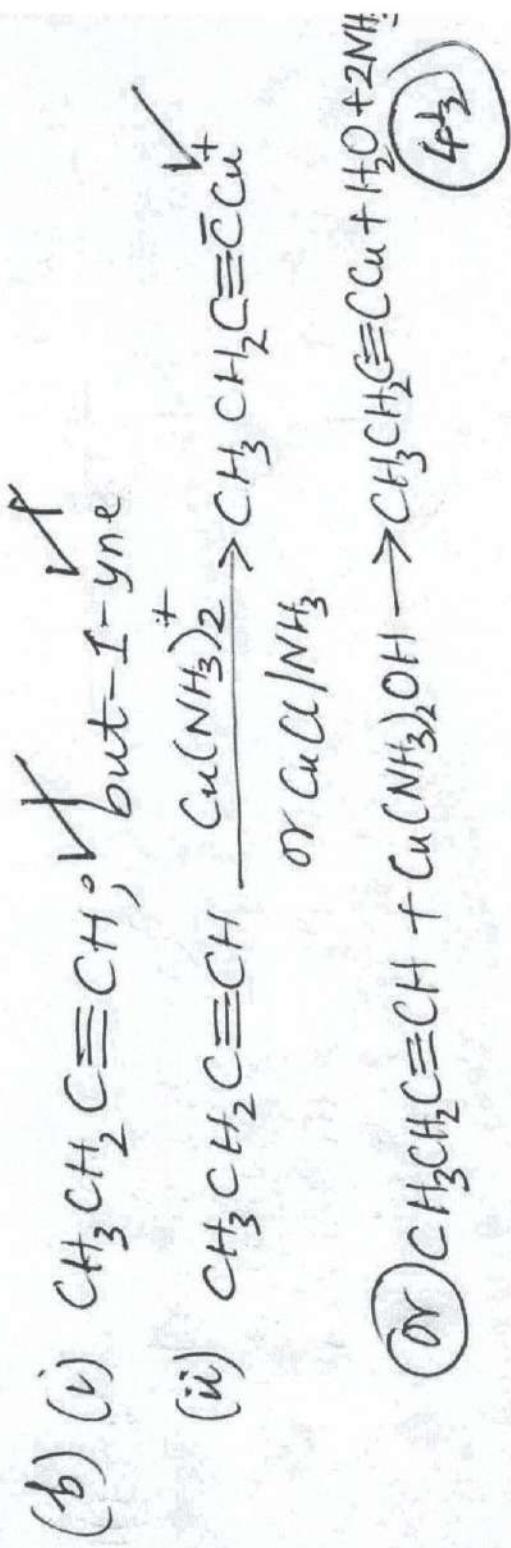
DB



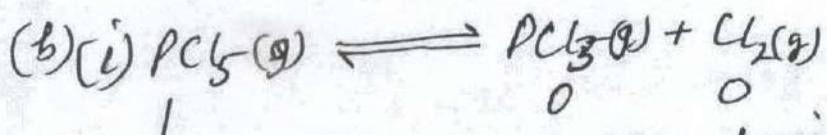
$$30x = 120 \Rightarrow x = 4 \quad \checkmark$$

$$30\left(4 + \frac{y}{4}\right) = 165 \Rightarrow y = 6 \quad \checkmark$$

Q is $C_4H_6 \quad \checkmark$



$$7. (a) K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} \quad \checkmark \quad 0\frac{1}{2}$$



Let x moles of PCl_5 dissociate
 x $x \sqrt{t} \text{ (all)}$

Egn mol: $1-x$

$$\text{but } \frac{x}{1+x} \times 100 = 38.4$$

$$\frac{x}{x} = 0.623 \quad \checkmark \quad 0.623 \text{ L}(all)$$

Egn concn 0.377

$$K_c = \frac{(0.623)(0.623)}{0.377} = 1.03 \text{ mol}^{-1} \text{ L}^{-1} \text{ (with units)}$$

allow (ii) The forward reaction is exothermic, $\Delta H < 0$
 Consequently, increases with decrease in temperature ΔT

(c) Concentration of Cl_2 increases \checkmark
Decrease in pressure shifts equilibrium position from left to right, since forward reaction proceeds with increase in volume
Thus more PCl_5 decomposes to form more chlorine and $1\frac{1}{2} PCl_3$

53

8(a) Reagent: Fehling's solution ✓ (or And heat) $\xrightarrow{\text{mobile}}$
 $\text{C}_6\text{H}_5\text{CHO}$; No observable change \checkmark even on heating
 $\text{CH}_3\text{CH}_2\text{CHO}$; Reddish-brown ppt/solid on warming
reject without heat
reject Ammoniacal silver nitrate solution.

(b) Ice-cold mixture of sodium nitrite and concentrated hydrochloric acid \times reject accept $\left(\begin{array}{l} 0^\circ\text{C} / 0-10^\circ\text{C} / \leq 10^\circ\text{C} \\ \text{for ice-cold} \end{array} \right)$

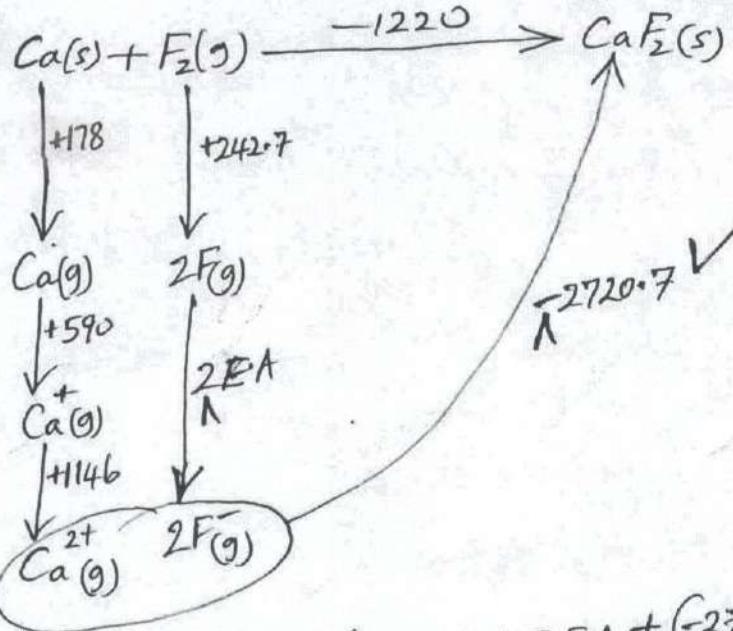
$(\text{CH}_3)_2\text{CHNH}_2$; colourless solution \checkmark and bubbles of a colourless gas \checkmark

$(\text{CH}_3)_2\text{NH}$; yellow oil \checkmark

05



9. (a)



- energy terms included
- physical states are correct
- eqns balanced

$$(+178) + (+590) + (+1146) + (+242.7) + 2E.A + (-2720.7) = -1220$$

$$2E.A = -648$$

$$E.A = -324 \text{ kJ mol}^{-1}$$

ignore with no (or)
wrong units

$$(b) \Delta H_{\text{solution of }} \underline{\text{CaF}_2} = \Delta H_{\text{hydration of }} \underline{\text{CaF}_2} + \text{Lattice energy of } \underline{\text{CaF}_2}$$

$$= (-1587) + (2 \times -515) + 2720.7$$

$$= +103.7 \text{ kJ mol}^{-1}$$

ignore with no (or)
wrong units

- (c) (i) Increase in temperature increases the solubility of CaF_2 ✓ reject if (b) is -ve or sign not indicated
- award even if
(b) is a wrong +ve
- (ii) Heat of solution is positive endothermic

55

Subject.....

Paper code.....

Room No.

Personal Number

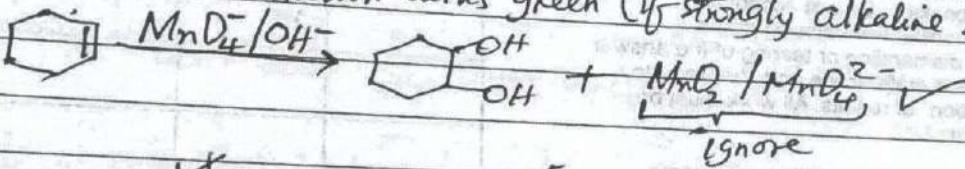
Free writing is not
permitted on page 2

10. (a) Effervescence occurs and ~~brown, violet~~ ^{violet} vapours evolved
~~or~~ $2\text{NaI}(s) + 3\text{H}_2\text{SO}_4(l) \rightarrow 2\text{NaHSO}_4(l) + 2\text{H}_2\text{O}(l) + \text{SO}_2(g) + \text{I}_2(g)$

- (b) Reddish-brown ppt/solid or red ppt.
 $\text{CH}_3\text{CH}_2\text{CHO}$ Fehling's solution $\xrightarrow{\text{boil}}$ $\text{CH}_3\text{CH}_2\text{COO}^- + \text{Cu}^{2+}$

- (c) Solution turns brown/yellow/reddish-brown
 $\text{Cl}_2(g) + 2\text{Fe}^{2+}(aq) \rightarrow 2\text{Fe}^{3+}(aq) + 2\text{Cl}^-(aq)$

- (d) Purple solution turns colourless
 allow: purple solution forms a brown/black ppt (in neutral
 or mildly alkaline solution)
 purple solution turns green (if strongly alkaline solution)



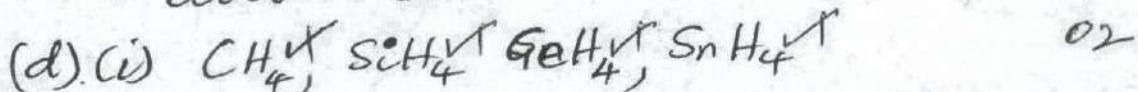
- (e) Orange solution turns green
 $\text{Cr}_2\text{O}_7^{2-}(aq) + 3\text{NO}_2^-(aq) + 8\text{H}^+(aq) \rightarrow 2\text{Cr}^{3+}(aq) + 3\text{NO}_3^-(aq) + 4\text{H}_2\text{O}(l)$

02

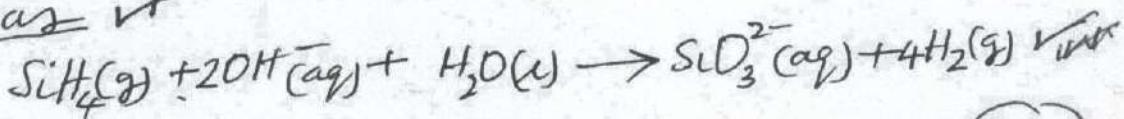
(09)

11. (a) $ns^2 np^2$ ✓ O_2
- (b) Metallic character increases down the group
(or from C to Sn)
From C \rightarrow Sn, atomic radius increases. Effective nuclear charge of the nucleus decreases and the $1/2$ nuclear attraction for the outermost decreases. Thus, the tendency for the atoms to lose outermost electrons increases from C \rightarrow Sn.

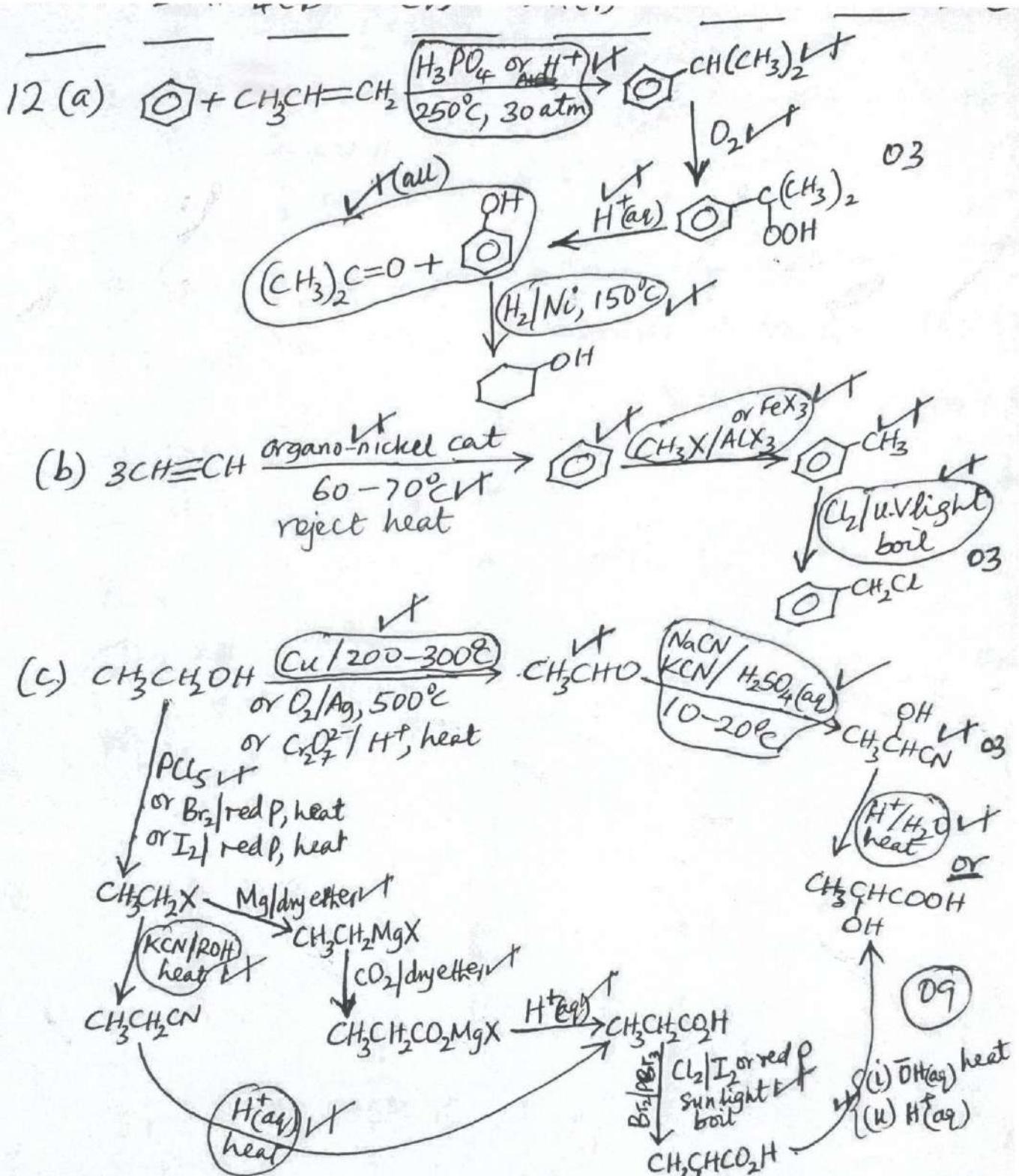
- (c) (i) - Carbon atom has the smallest atomic radius / highest any two electronegativity / very high first ionisation energy
correct - Carbon atom lacks easily accessible d-orbitals
- (ii) - Has a maximum covalency of 4 while the others can expand their octets to a maximum valency of 6
- catenates unlike the other elements ✓
- Forms stable multiple bonds with itself and any two other elements.
correct - Forms gaseous oxides unlike the other elements which form solid oxides
- forms Cpd's which are relatively inert unlike the others
- does not show inert pair effect unlike the others



- (ii) Only SiH_4 reacts with cold water in presence of an alkali to form silicate ions and hydrogen gas ✓



09
Max 09
12



NB: Stop marking if reagent/condition/intermediate is wrong

(3)

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^2$ (or) $- - - 4s^2 3d^5$

01

- (b) (i) - Potassium manganate(VII) is a powerful oxidising agent
- It does not require an indicator
- Has fairly high relatively formula mass
- It is readily available reject stable in air
(ii) Iron(II) ammonium sulphate - 6 water ✓ 01
or Anhydrous ammonium oxalate or ethanedioate

(c) (i) Purple solution turns brown ✓

2 $\frac{1}{2}$



(ii) Purple solution turns colourless and bubbles of a
colourless gas. ✓



Ques

14(a)

Is the precipitation of a sparingly soluble ionic compound (or electrolyte) from its saturated solution by adding (or adding electrolyte) a solution of a more soluble ionic compound containing one of the ions contained by the sparingly soluble ionic compound at a given temperature.

(block
mark)

— — — on addition of an electrolyte solution which has an ion in common with the solute containing a similar cation/anion (or one of the ions)

UGANDA NATIONAL EXAMINATIONS BOARD
 NOVEMBER - DECEMBER, 2020

0.0233M Page 5

UACE

Do not
write
in this
margin

Candidate's Name

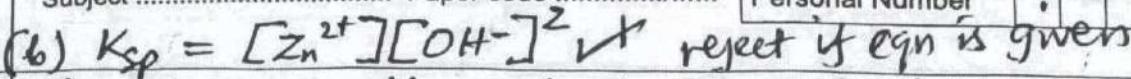
Signature

Subject

$$\frac{1}{2} \text{NaOH} = \text{4POT}^-$$

Arg CD

Random No.		
Personal Number	.	.

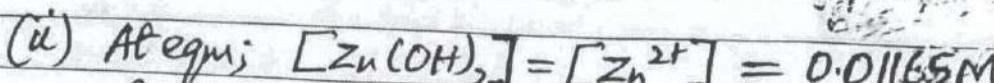


(c)(i) No of moles of acid = No of moles of $\text{OH}^- = \frac{5.6 \times 0.1}{1000} = 5.6 \times 10^{-4}$ ✓

$$[\text{OH}^-] = \frac{5.6 \times 10^{-4} \times 1000}{24.0} = 0.0233 \text{ M L}^+$$

$$[\text{Zn}^{2+}] = \frac{0.0233}{2} = 0.01165 \text{ M L}^+ \text{ or } 0.0117 \text{ M L}^+$$

$$K_{sp} = (0.01165)(0.0233)^2 = 6.32 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}$$



$$\text{Rfm of } \text{Zn}(\text{OH})_2 = 65.7 + 2(17) = 99.7 \text{ L}^+$$

$$\text{Mass of } \text{Zn}(\text{OH})_2 \text{ dissolved} = 99.7 \times 0.01165 = 1.161505 \text{ g}$$

$$\% \text{ of } \text{Zn}(\text{OH})_2 \text{ dissolved} = \frac{1.161505}{5.0} \times 100 = 23.2301 \% \text{ or } 23.23 \%$$

(d)(i) Solubility would reduce/ decrease

~~Concentration of zinc ion increases due to common ion effect. This leads to the reaction between excess zinc ions and hydroxide ions to form solid zinc hydroxide (or precipitate zinc hydroxide)~~

(ii) Solubility would increase, ✓

~~Addition of ammonia leads to the reaction between zinc ions and ammonia molecules to form a soluble complex ion. The concentration of zinc ions in solution reduces and thus more solid zinc hydroxide dissolves to restore the equilibrium and keep K_{sp} constant.~~

~~Not all complexes are soluble?~~ ✓

~~Solution reduces and thus more solid zinc hydroxide dissolves to restore the equilibrium and keep K_{sp} constant.~~

reject without ~~soluble~~ complex ion

HMC 3
UGANDA NATIONAL EXAMINATIONS BOARD
NOVEMBER - DECEMBER, 2020

Candidate's Name

Signature

Subject

CH_3COCl or Br not I
Paper code

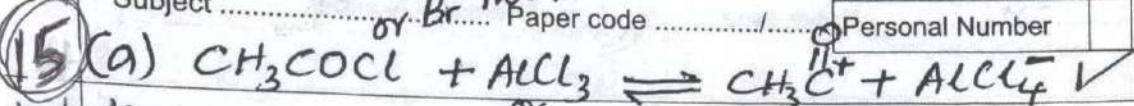
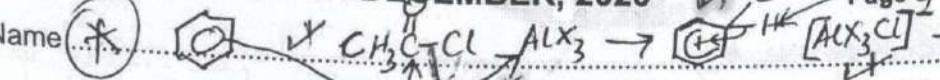
Random No.			
Personal Number			

UACE

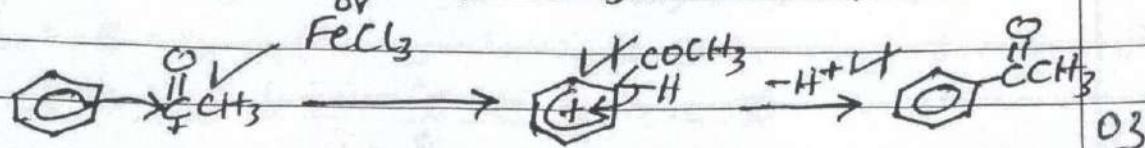
Do not
write
in this
margin

✓

Page 3

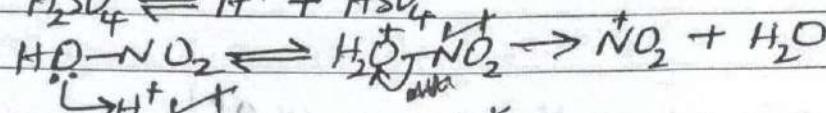
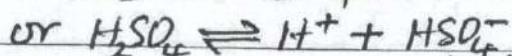
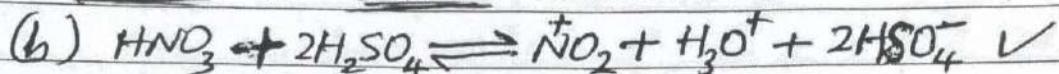


details
in mechanism
=

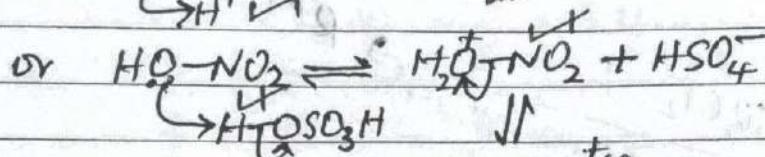


03

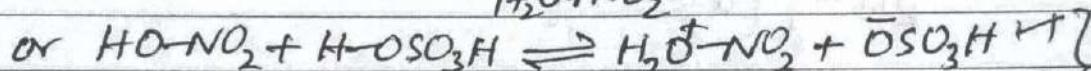
allow other correct alternatives



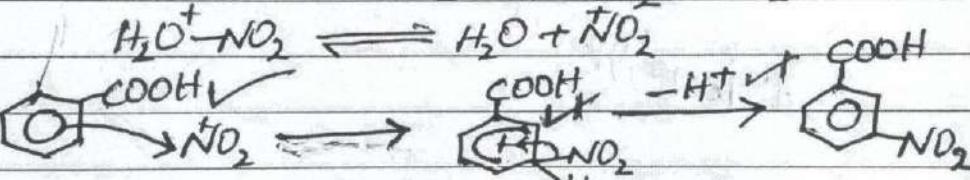
brace with
cancel arrows



03

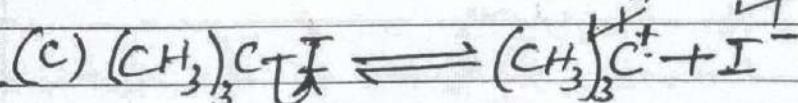


brace with
NO
emphasis
on arrows

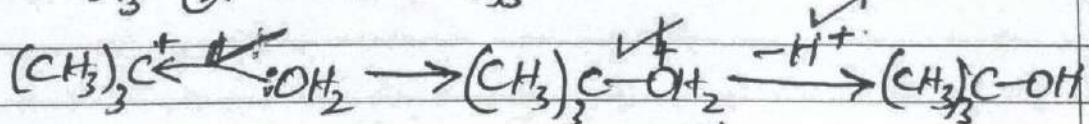


reject use of
 NaOH(aq)

03



reject use of



N.B.: Stop marking if answers are wrongly drawn
or intermediate is wrong

16(a)(i) Relative lowering of the vapour pressure of a pure solvent is directly proportional to the mole fraction of the non-volatile solute dissolved in it to make a dilute solution at a given temperature. ✓ 01

or The ^{partial} V.P of any volatile component in a solution is equal to the V.P of pure component multiplied by mole fraction of that component in solution (over the whole concentration range) at all temperatures.

or $P_A = x_A P_A^0$ at a given temperature

where P_A is the ^{partial} V.P of the component A

x_A " " mole fraction of the component A

P_A^0 " " V.P of the pure component A or SVP of A.

- (ii)-The intermolecular forces between like and unlike molecules are equal in strength/magnitude
 - formed without change in heat fenthalpy ✓
 - formed without change in total volume, ✓
 - obeys Raoult's law of vapour pressure

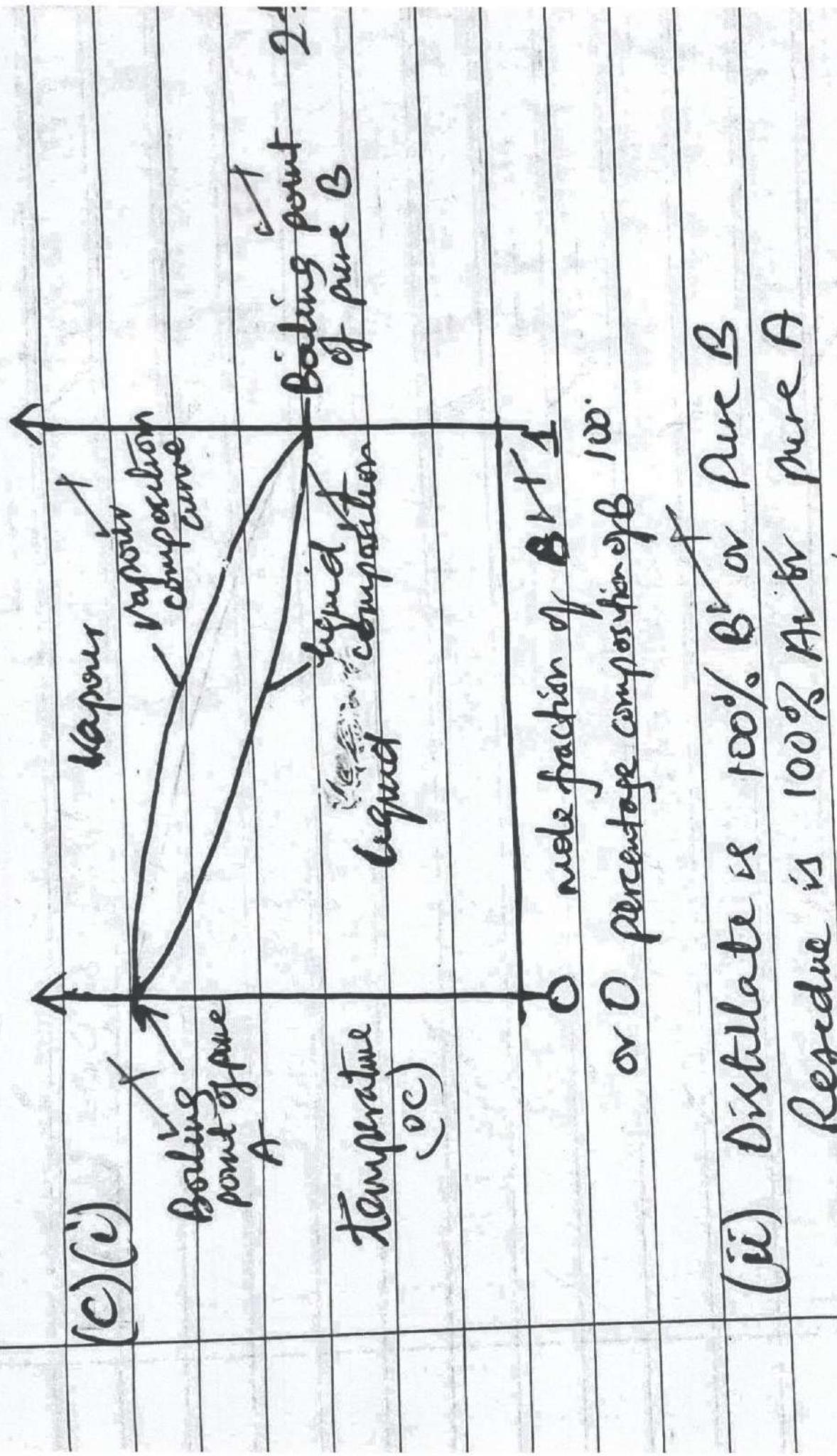
$$(b) P_A = x_A \cdot P_A^0 = (0.25 \times 8.000) \text{ kPa} = 2.000 \text{ kPa} \checkmark$$

$$P_B = (1-0.25)(13.332) \text{ kPa} = 9.999 \text{ kPa} \checkmark$$

$$P_T = P_A + P_B = (2.000 + 9.999) \text{ kPa} = 11.999 \text{ kPa} \checkmark \quad 0.5$$

$$\text{Composition of A in vapour} = \frac{P_A}{P_T} = \frac{2}{11.999} = 0.1667 \checkmark \quad \text{or } 16.67\%$$

$$\text{Composition of B in vapour} = 1 - 0.1667 = 0.8333 \checkmark \\ \text{mole fraction of} \quad \text{or } 83.33\%$$



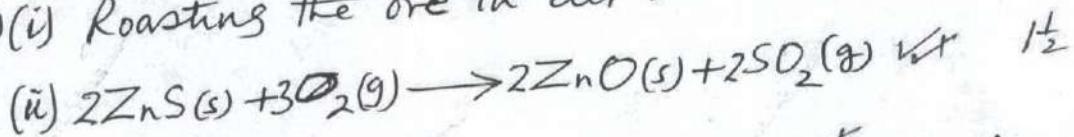
or mole fraction of B = 1
or 0 percentage composition of B = 100%

(ii) Distillate is 100% B or pure B
Residue is 100% A or pure A

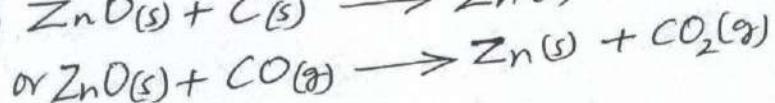
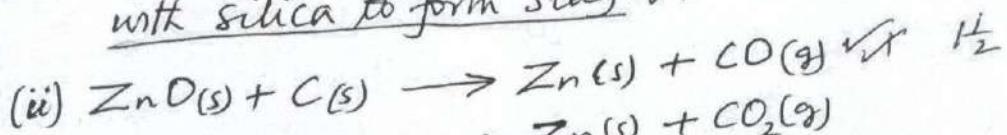
17 (a) (i) Zinc blende, ZnS ✓ 01
or Zinc carbonate, $ZnCO_3$

(ii) froth flotation ✓ 0½ or floatation

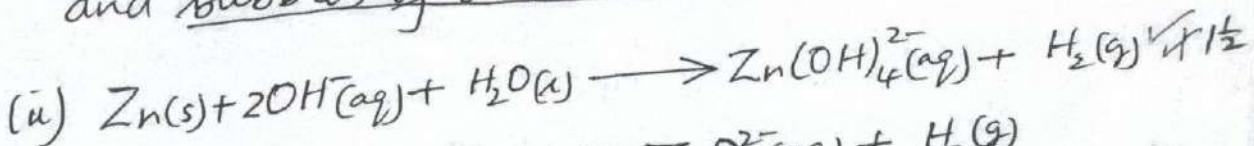
(b) (i) Roasting the ore in air ✓ 0½



(c) (i) Decomposes to form calcium oxide which then reacts with silica to form slag. ✓ 01



(d) (i) Grey solid dissolves to form a colourless solution and bubbles of a colourless gas ✓ 1½



09

BUGANDA MOCKS 2023

Draft Guide - 2023 CHEMISTRY P525/2

- 1(a)(i) The number of times the ^{average} mass of a naturally occurring atoms of an element is heavier than a twelfth of the mass of an atom of carbon-12 isotope of carbon.
- (ii) Half-life is the time taken by a reactant to reduce to half its original amount. ✓ or time taken for half the original mass of a radioactive substance to decay.
- (b) The vapourised sample is introduced into the ionisation chamber where it is bombarded by fast moving and high energy electrons to form positive ions. ✓
 The positive ions are accelerated to high and same ^{constant} velocity (or speed) by the electric field into the magnetic field which deflects them into circular paths according to the mass to charge ratio [✓] on to the ion collector.
 The strengths of both the electric and magnetic fields are varied so that ions of a given mass are received at the detector. ✓
 The collected charges are amplified into a sizeable current which operates a pen and draws the mass spectrum of copper. The number of peaks/lines depends on the number of isotopes in the sample and the heights of peaks/lines depend on the abundances of the isotopes. ✓

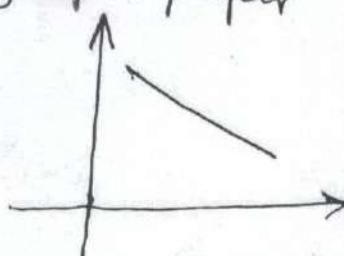
$$RAM = \frac{\sum (\text{isotopic mass} \times \text{relative abundance})}{\sum (\text{relative abundance})}$$

(c) Let the relative abundance of Cu-62.93 be x
 \Rightarrow " " " " Cu-64.93 = $(100-x)$ ✓
 $\Rightarrow 63.5 = \left(\frac{x}{100} \times 62.93\right) + \left(\frac{100-x}{100} \times 64.93\right)$ ✓ Q2
 $63.5 = 62.93x + 64.93 - 64.93x$
 $x = 71.5$ ✓ ✓
 \therefore Cu-62.93 is 71.5% and Cu-64.93 is 28.5%. ✓

①

time (minutes)	20	40	60	80	100	120
log(mass)	1.683	1.585	1.498	1.415	1.322	1.236

Refer to graph paper



axes ✓
plots ✓
shape ✓
Title it

all
3 d.p.s
reject 1 d.p.
or 2 d.p.s

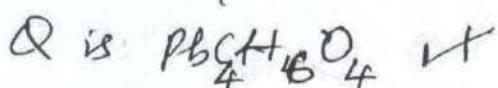
(e)(i) At $t=0$; $\log m_0 = \frac{1.8}{1.6-1.9} \checkmark \Rightarrow m_0 = 10^{1.7672} = 58.5 \text{ g with units}$
allow $(58.5 \rightarrow 63.1 \text{ g})$

(ii) From $\log_{10} a_t = -\frac{k}{2.303} t + \log_{10} a_0$ (ignore)
Slope = $-0.0044 \text{ minute}^{-1} \checkmark$ expression
 $\Rightarrow -\frac{k}{2.303} = -0.0044 \checkmark \Rightarrow k = 1.01332 \times 10^{-2} \text{ minute}^{-1}$ answer + units 2½

(iii) $t_{\frac{1}{2}} = \frac{\ln 2}{k} \checkmark = \frac{\ln 2}{1.01332 \times 10^{-2}} = 68.4 \text{ minutes } 1\frac{1}{2}$
allow $(67 \rightarrow 69)$

$$2(a)(i) \% \text{ of O} = 100 - (63.0 + 14.8 + 1.8) = 20.4$$

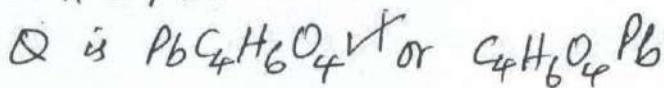
No of moles	Pb : C : H : O
	$\frac{63.0}{207}$ $\frac{14.8}{12}$ $\frac{1.8}{1}$ $\frac{20.4}{16}$
	0.304 1.233 1.8 1.275 ✓
Atomic ratio	$\frac{0.304}{0.304}$ $\frac{1.233}{0.304}$ $\frac{1.8}{0.304}$ $\frac{1.275}{0.304}$
	1 4 6 4 ✓



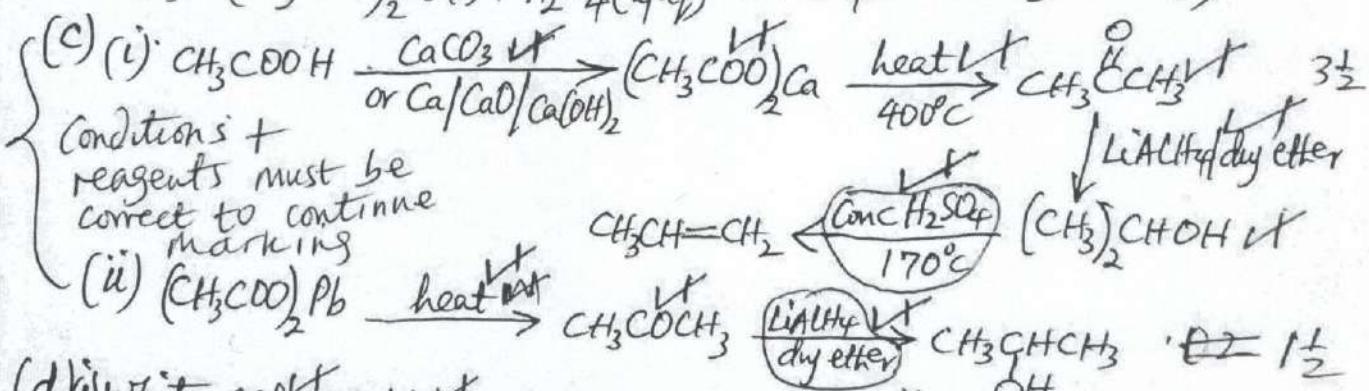
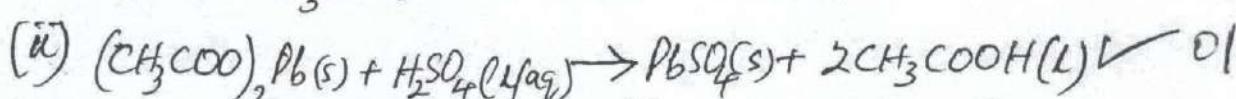
$$(ii) (PbC_4H_6O_4)_n = 325$$

$$[207 + (12 \times 4) + 6 + (4 \times 6)]n = 325 \quad 01$$

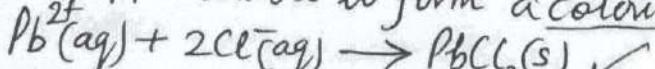
$$n = 1 \quad \checkmark$$



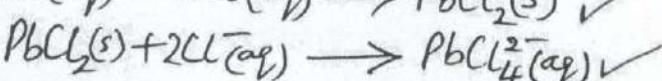
(b) (i) T is $PbSO_4$ for lead(II) sulphate 01
N is CH_3COOH for ethanoic acid



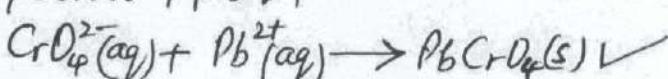
(d) (i) White ppt ✓ soluble to form a colourless solution



3½

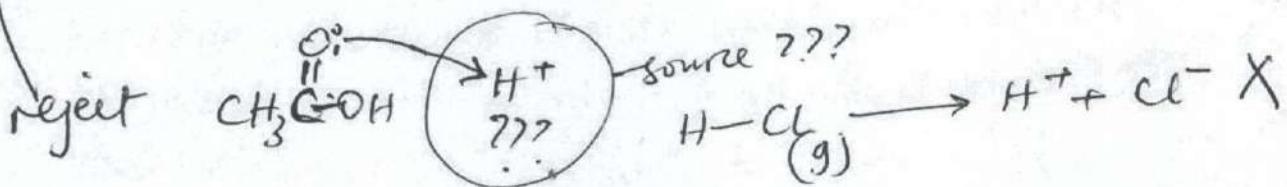
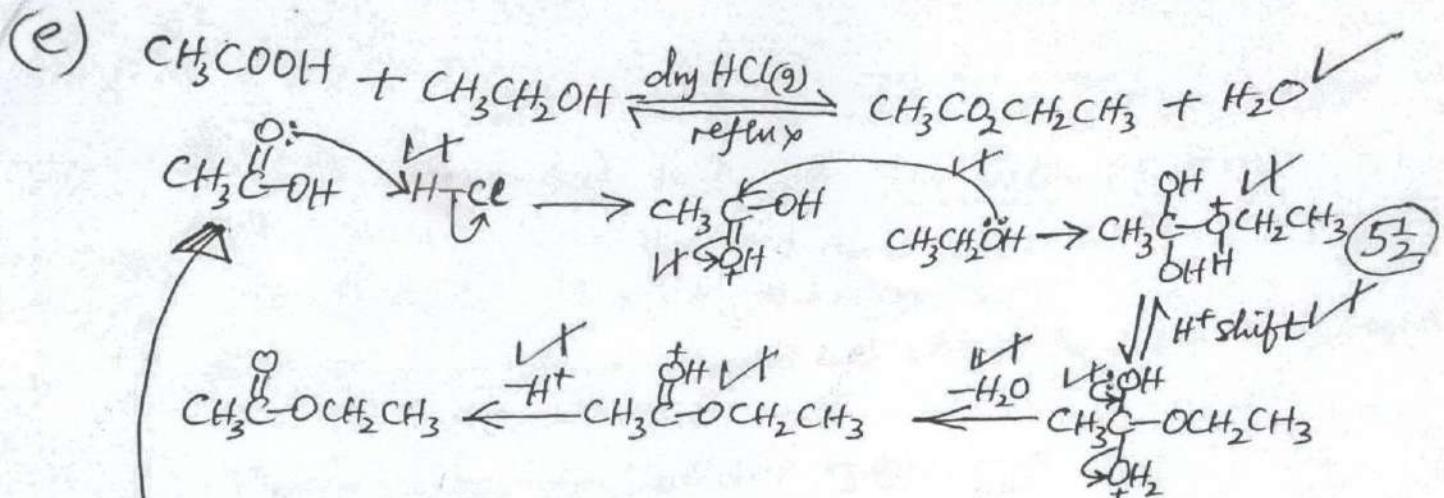


(ii) Yellow ppt ✓



1½

③



Intermediates must be correct to continue marking

3

(a)(i) The partial vapour pressure of a (volatile) component in an ideal liquid mixture (or ideal solution) is the product of its vapour pressure when pure and its mole fraction in the solution at a given temperature ✓
ignore

accept: The relative lowering of the vapour pressure of a pure solvent (or of the solution) is equal to the mole fraction of the non-volatile solute dissolved in it at a given temperature ✓

(ii) A liquid mixture in which the cohesive forces are equal in strength to adhesive forces. It is formed 02 with no change in temperature (or heat) and total volume! The liquid mixture obeys Raoult's law ✓

$$(b) (i) P_p = x_p P_p^0 = 1521 \times \frac{0.21}{0.8} = 380.25 \text{ mmHg}$$

$$P_Q = x_Q P_Q^0 = 570 \times \frac{0.61}{0.8} = 427.5 \text{ mmHg} \quad 03$$

$$\text{V.P. of mixture} = 427.5 + 380.25 = \underline{\underline{807.75 \text{ mmHg}}} \quad \checkmark \text{ both}$$

$$(ii) x_p = \frac{P_p}{P_{\text{Total}}} = \frac{380.25}{807.75} \checkmark 0.4708 \quad (\text{or } 47.08\%)$$

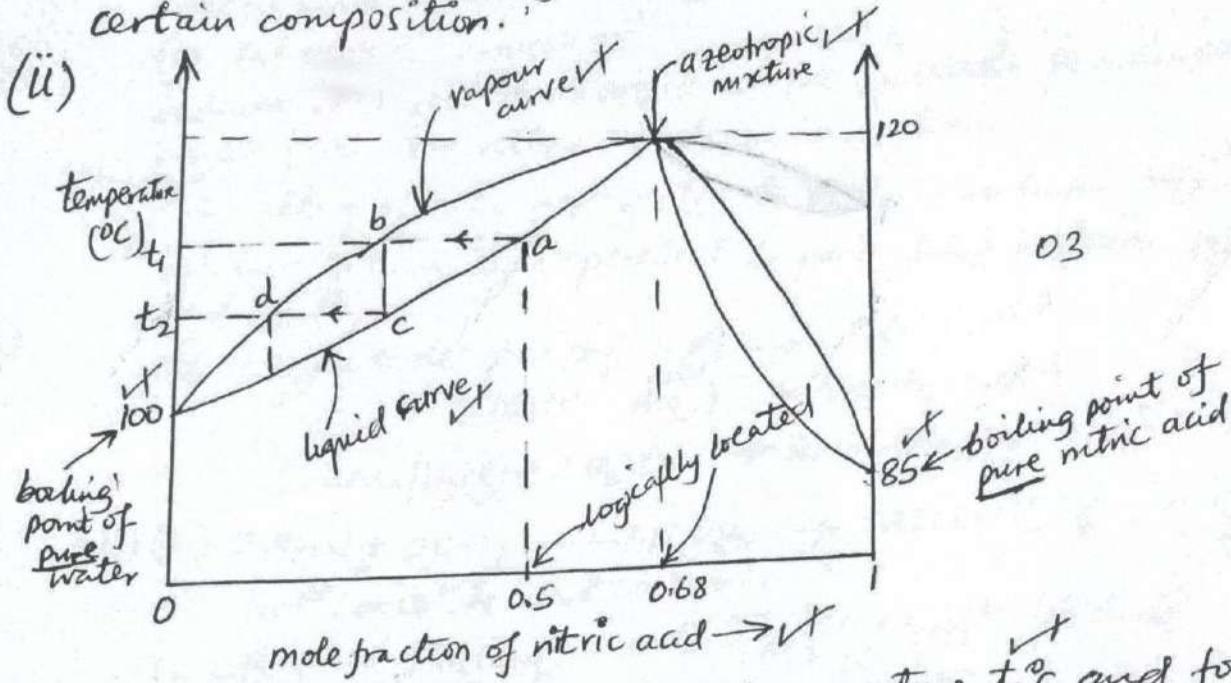
$$x_Q = \frac{P_Q}{P_{\text{Total}}} = \frac{427.5}{807.75} \checkmark 0.5292 \quad (\text{or } 52.92\%) \quad 02$$

$$(\text{or } x_Q = 1 - 0.4708 = 0.5292)$$

(c)(i) The forces of attraction between molecules of nitric acid and water are stronger than those that exist between molecules of nitric acid and water molecules in separate pure states.

This leads to less escaping tendency of molecules of each kind ^{from the liquid mixture} into vapour than from the pure liquids
 (or if it was ideal) 03

The vapour pressure of the solution is lower than that of an ideal solution leading to a maximum boiling point at a certain composition.



When heated, it boils at 'a' at temperature, $t_1^{\circ}\text{C}$ and forms a vapour^{of composition} 'b' which is richer in water, the more volatile component. The vapour cools to form a liquid 'c' which has the same composition as the vapour. The liquid mixture again boils at a lower temperature, $t_2^{\circ}\text{C}$ to form a vapour which is still richer in water! When the process of boiling and condensing is repeated times, pure water is formed as a distillate. The azeotropic mixture is formed as a residue.

(iii) 1cm^3 of mixture (or solution) contains 1.42g of acid
 1000cm^3 of mixture contain $(1.42 \times 1000)\text{g}$ of acid
 $= 14200\text{g}$ of acid

Mass of acid in 1 litre of solution = $\left(\frac{68}{100} \times 1420\right)\text{g} = 9.656\text{g}$ 03

Rfm of $\text{HNO}_3 = 1 + 14 + (16 \times 3) = 63$

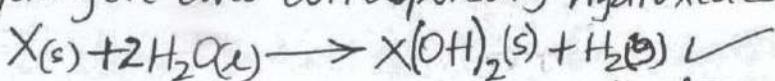
Molarity of stock $\text{HNO}_3 = \frac{9.656}{63}\text{M} = 15.327\text{M}$

Volume of acid = $\frac{2 \times 1000}{15.327} = 130.9\text{cm}^3$

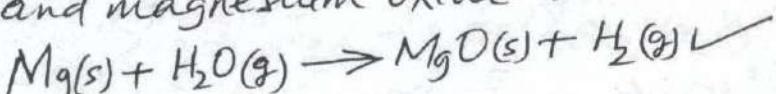
2

4(a)(i) Beryllium doesn't react with water at all conditions

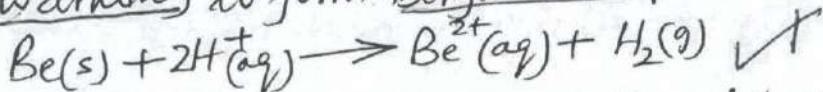
The rest (Mg, Ca, Ba) react with cold water to form hydrogen and corresponding hydroxides ✓



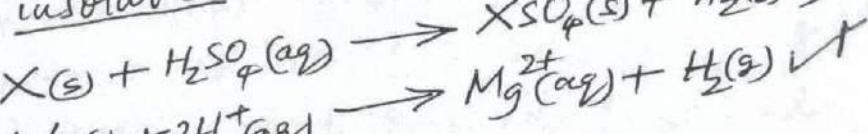
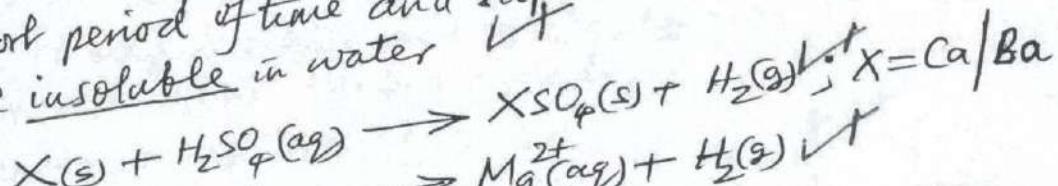
Heated magnesium reacts with steam to form hydrogen and magnesium oxide ✓



(ii) Beryllium reacts with dilute sulphuric acid on warming to form beryllium sulphate and hydrogen ✓



The rest react with cold dilute sulphuric acid to form the corresponding sulphate and hydrogen. ✓
The reaction with Ca and Ba takes place for a short period of time and stops since their sulphates are insoluble in water ✓



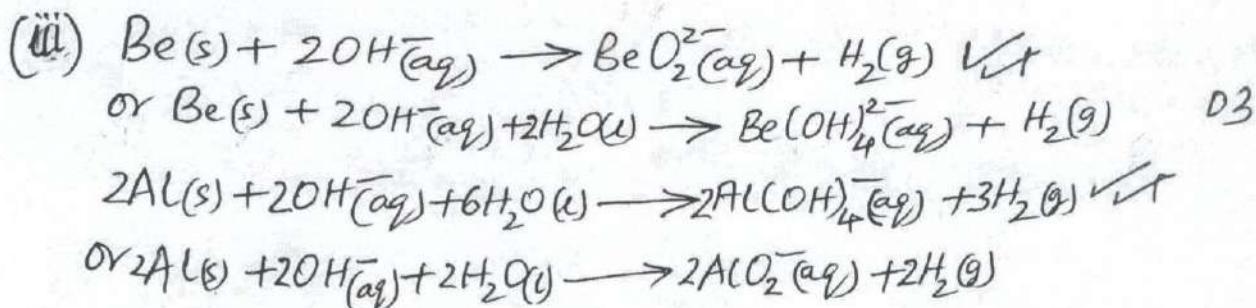
(b)(i) - Both elements are made passive by nitric acid. ✓

- Their oxides (or hydroxides) are amphoteric. ✓

- Their carbides hydrolyse in water to give methane and the corresponding hydroxide. ✓

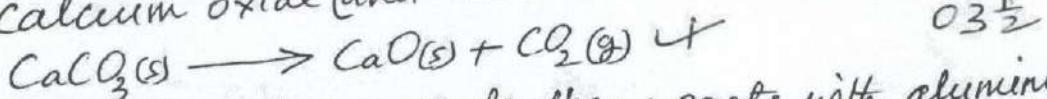
any correct 3 points - Their chlorides are covalent polymeric solids when anhydrous.
- Their chlorides exist as dimers in vapour phase

- (ii) - The atom has the smallest atomic radius/highest electronegativity (or least electropositivity)
- The cation has the highest charge density (or polarising power)
 - The element has the least negative value of SEP

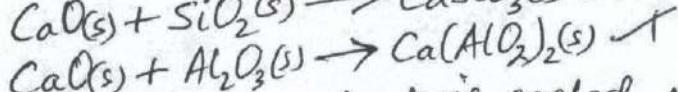
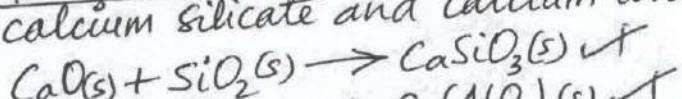


- (c) (i) Dry process ✓ and wet process ✓
 (ii) Limestone & clay and gypsum ✓ 01
 1½

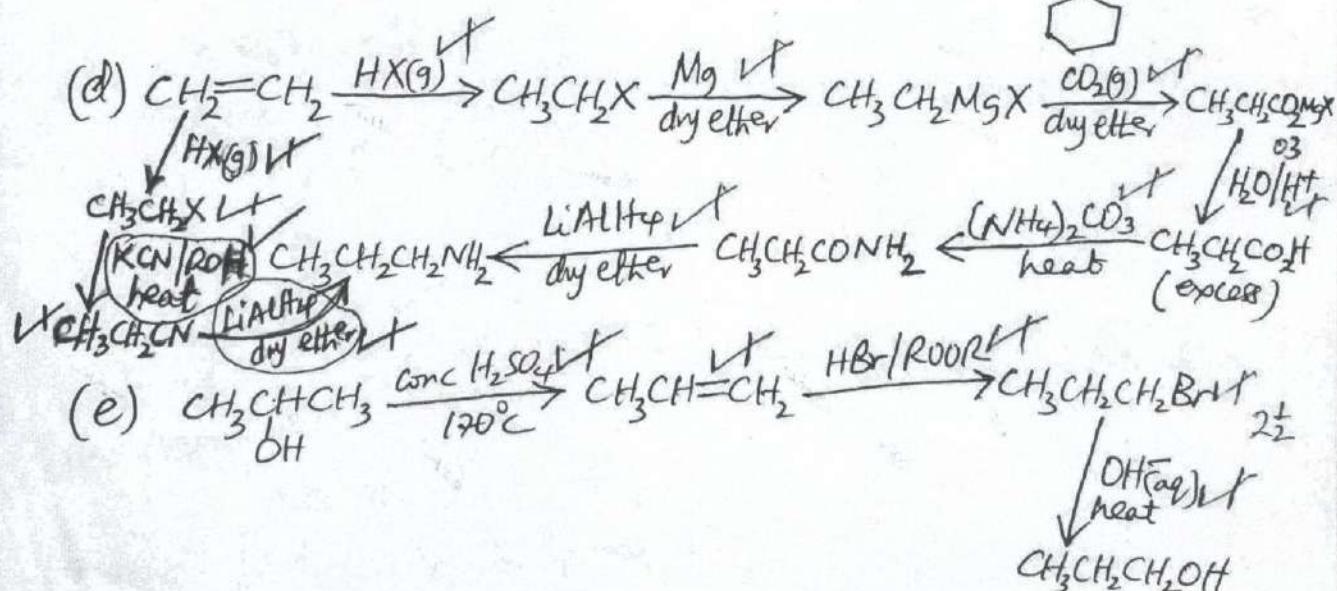
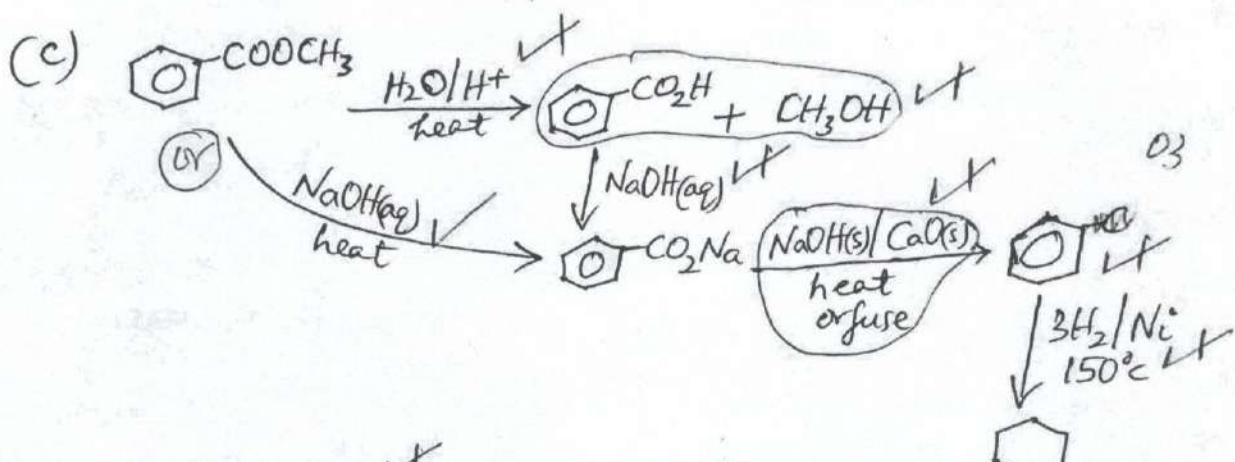
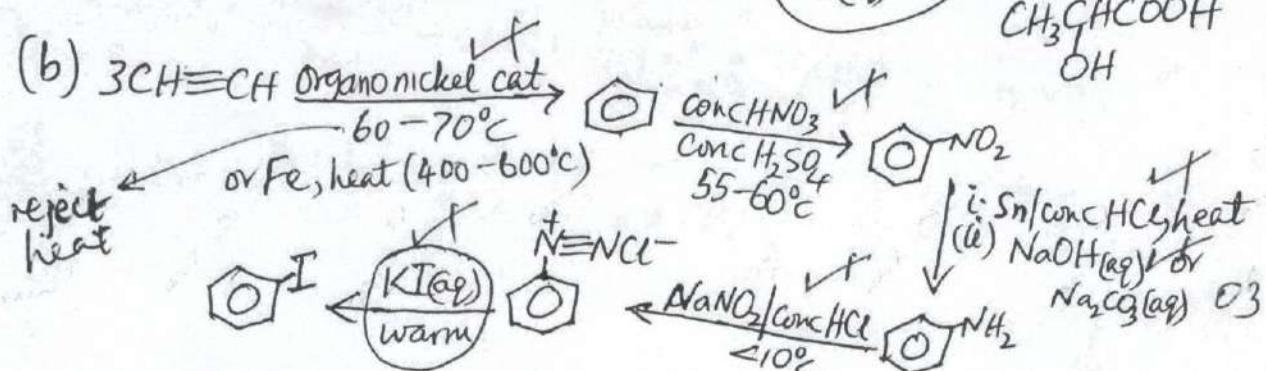
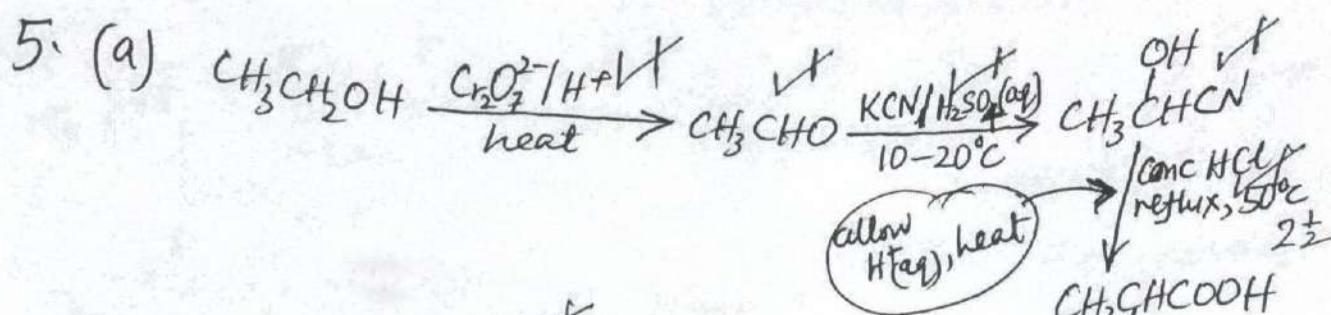
(b) A mixture of limestone and clay is powdered and strongly heated to expel water and decompose limestone to calcium oxide (and carbon dioxide)



The basic calcium oxide then reacts with aluminium oxide and silicon(IV) oxide in clay to form a mixture of calcium silicate and calcium aluminato

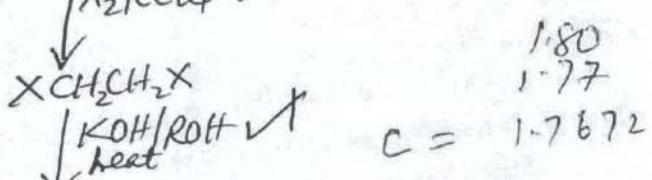
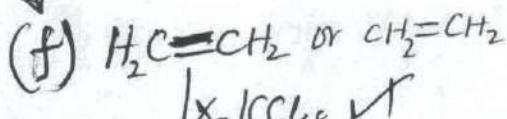
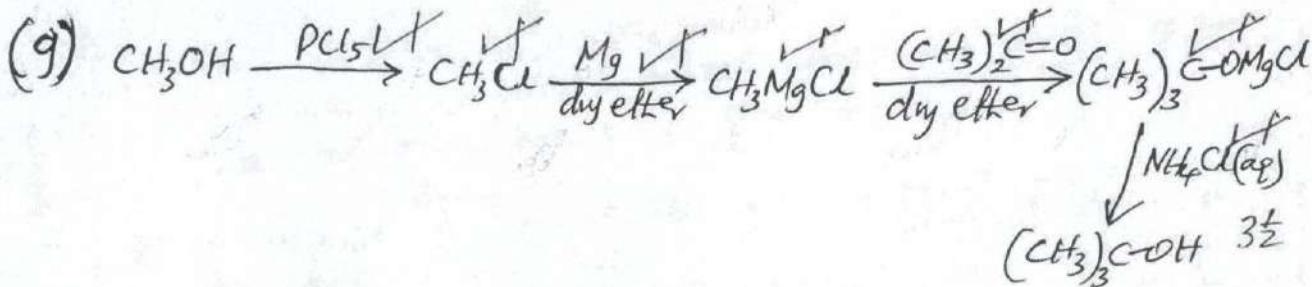
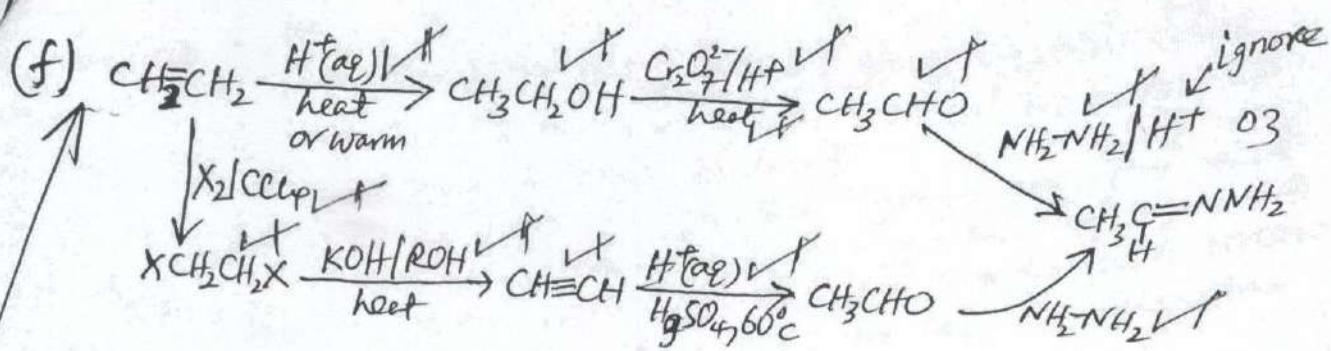


The roasted product is cooled, powdered and mixed with some gypsum and other materials to form cement

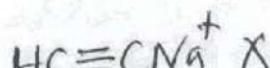
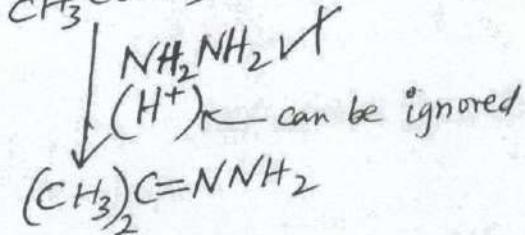
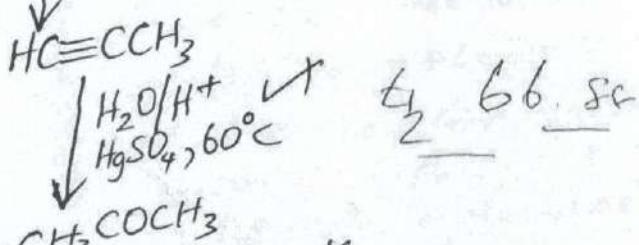
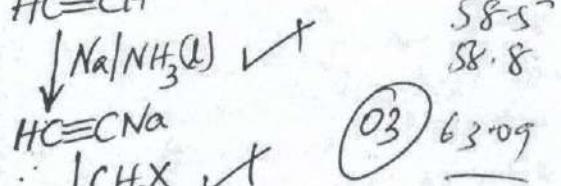
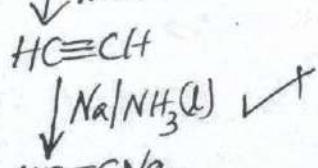


(P)

九



$$C = 1.7672$$



$$\text{Slope} = -0.0044 \\ 4.5 \times 10^{-3}$$

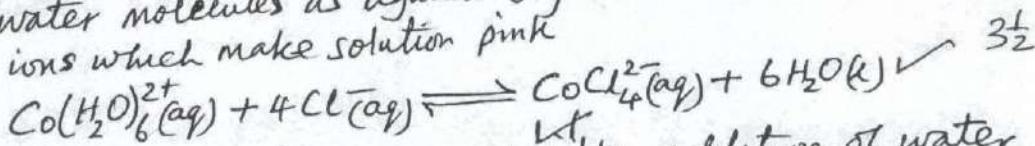
$$\mu = 00103635^\circ$$

N.B.: In (a) → (f); accept After correct alternative routes. All reagents and conditions must be correct to continue marking

6. (a) In $\text{C}_6\text{H}_4(\text{NO}_2)_2$, the two functional groups are wide apart and as a result, molecules of 4-nitrophenol associate via intermolecular hydrogen bonds. In 2-nitrophenol, the two functional groups are close and this results into intramolecular hydrogen bonding. Hence, $\text{C}_6\text{H}_3(\text{NO}_2)_2$ molecules of 2-nitrophenol associate via van der Waals forces of attraction. (allow: Hence, there are less intermolecular hydrogen bonds in 2-nitrophenol). Hydro: Intermolecular hydrogen bonds are stronger than van der Waals forces of attraction.

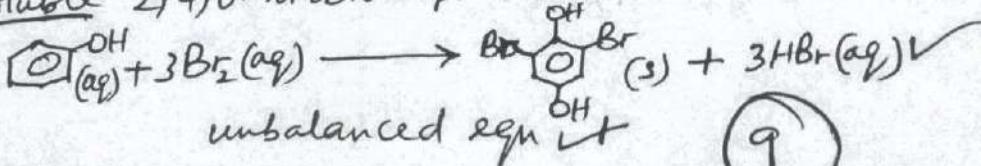
(b) The hydrogen bonded to the carbonyl group in methanoic acid has no inductive effect. oxygen-hydrogen bond is relatively weaker whereas in ethanoic acid, the methyl group which is bonded to the carbonyl group has a positive inductive effect. The CH_3 methyl group pushes electrons towards the oxygen-hydrogen bond and this reduces the partial positive charge on the hydrogen atom and thus, strengthens the oxygen-hydrogen in ethanoic acid. Therefore, methanoic acid ionises more easily than ethanoic acid does.

(c) The pink colour of the aqueous solution of cobalt(II) chloride is due to the hexaqua cobalt(II) ions. On addition of concentrated hydrochloric acid, the chloride ions displace water molecules as ligands to form tetrachloro cobaltate(II) ions which make solution pink.

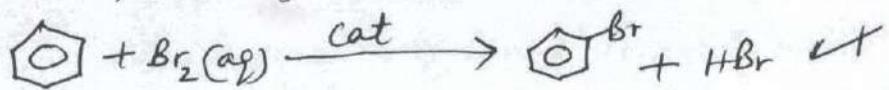


Since the reaction is reversible, addition of water causes the displacement of chloride ions as the ligands by the water molecules to form hexaqua cobalt(II) ions again.

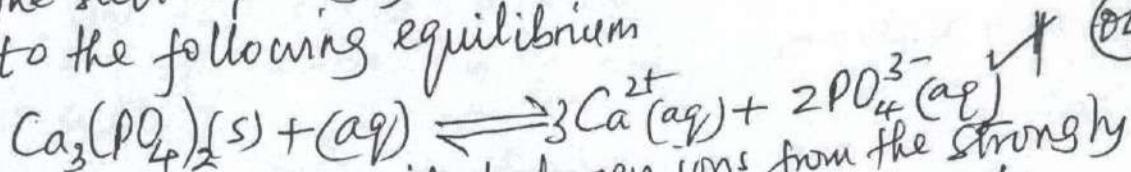
(d) In phenol, the lone pairs of electrons on the oxygen atom interacts with the delocalised electrons of the benzene ring. This increases the electron density in the ring and makes it more reactive. Thus, phenol readily undergoes electrophilic substitution with bromine water to form an insoluble 2,4,6-tribromophenol.



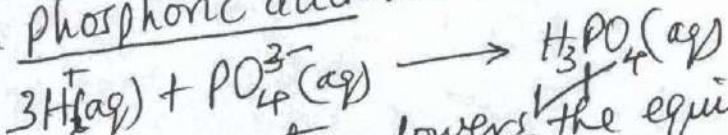
Benzene molecule lacks an electron donating group and this makes delocalised electrons in the ring not readily available for the electrophilic substitution in the ring. Thus, for the reaction to occur, a catalyst is added



(e) In Calcium phosphate, both ions are highly charged. This makes the salt have a high lattice energy that cannot be offset by the hydration energy released by the ions in aqueous solution. The salt sparingly dissolves in water according to the following equilibrium



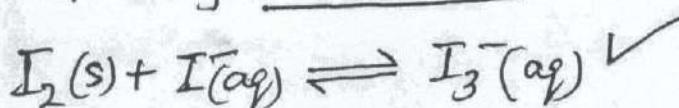
In dilute nitric acid, hydrogen ions from the strongly ionised acid reacts with the phosphate ions to form phosphoric acid which is a weak acid



The above reaction lowers the equilibrium concentration of phosphate ions and causes more solid calcium phosphate to dissolve.

(f) Iodine is non-polar whereas water molecules are non-polar.

Iodine reacts with iodide ions to form a soluble complex of triiodide ions



abv

NO7. (a)

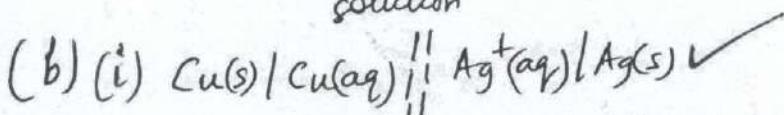
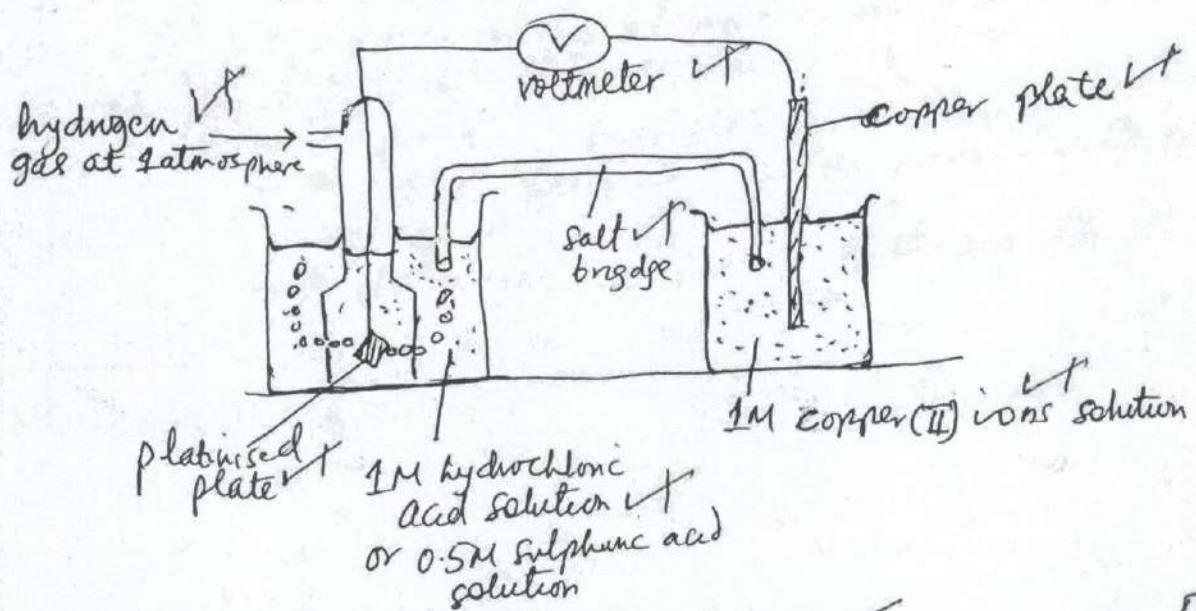
copper plate is dipped in a 1.0M solution of copper(II) ions (or copper(II) sulphate solution) to form a half cell.

The half cell is connected internally to the SHE via a salt bridge and externally to the SHE by use of a copper wire carrying a high resistance voltmeter or a potentiometer in series with two half cells.

The cell is allowed to stand at constant temperature of 25°C (or 298°C).

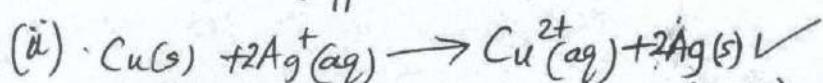
The emf of the cell is measured using a potentiometer. Since the SHE has a potential of 0.00 Volts, the reading of the potentiometer is the SEP of Copper and it is positive.

(D7)



01

01

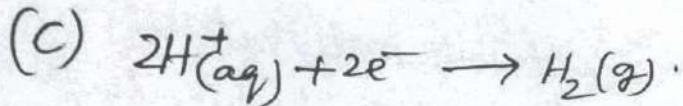


$$\begin{aligned} (\text{iii}) \quad \Delta G^\theta &= -nFE^\theta \\ &= -2 \times 96500 \times (+0.46) \quad E^\theta_{\text{cell}} = (+0.80) - (+0.34) = +0.46 \text{ V} \\ &= -88780 \text{ J mol}^{-1} \\ \text{or} &= -88.78 \text{ kJ mol}^{-1} \end{aligned}$$

03

(iv) The reaction is feasible since the ΔG^θ is negative

(11)



$$Q = 2.0 \times 30 \times 60 = 3600 \text{ C} \quad \checkmark$$

$$\text{No of moles of } H_2 \text{ evolved} = \frac{3600}{2 \times 96500} \quad \checkmark$$

$$V = \frac{nRT}{P} \quad \checkmark \quad \frac{3600 \times 8.31 \times (23+273)}{2 \times 96500 \times 100 \times 1000}$$

$$= 4.588 \times 10^{-4} \text{ m}^3$$

$$= 458.8 \text{ cm}^3 \quad \checkmark$$

03

- (d) (i) Electrochemical cells generate electricity from the electrode reactions; electrolytic cells need an external source of direct current O_2
- In electrolytic cells reduction occurs at the negative pole while in the electrochemical cells, oxidation occurs at the negative pole

- (ii)
- To predict feasibility of reactions \checkmark
 - To select the best suitable reducing (or oxidising) agents \checkmark O_3
 - To determine end-point in acid-base titrations

8(a) A d-block element is one in which the outermost electrons are filled in the d-subshell/sub-energy level / orbitals ✓

02

Transition element is one which forms at least one ion with a partially filled 3d orbitals / sub energy level ✓

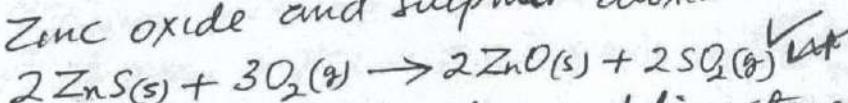
(or) An element with a partially filled 3d sub energy level in any of the stable oxidation states including the atomic state

(b) - Forms complexes (or complex ions) ✓ {Ignore qn has
- Its cpds can be used as a catalyst ✓ } an error

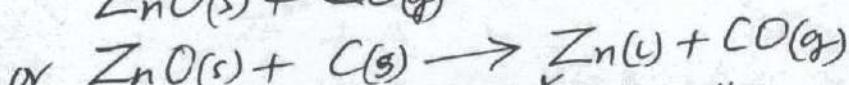
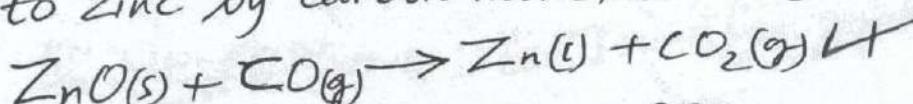
(c)(i) ZnS ✓ 01

(ii) The ore is crushed and mixed with water and a frothing agent. ✓ Air is blown through the mixture to agitate it; sink to the bottom while the ore with frothing agent float on top on the mixture from where they are skinned off and dilute acid is added to break the froth. The concentrated ore is filtered and dried. The purified ore is roasted in air to form Zinc oxide and sulphur dioxide

(D71)



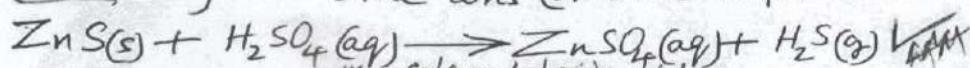
Zinc oxide formed, coke and limestone are dropped into a blast furnace. Hot air is blown into the furnace. (to heat the mixture where) Zinc oxide is reduced to zinc by carbon monoxide or carbon



Zinc vapour distills off from the vapour and is cooled (or condensed) by a spray of molten lead. ~~water~~
Zinc is purified by redistillation ✓

Alternatively

The ore is crushed and dissolved in excess dilute sulphuric acid to form zinc ions (or zinc sulphate solution)

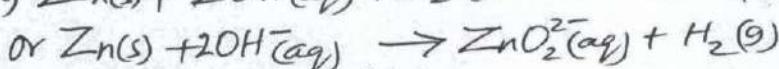
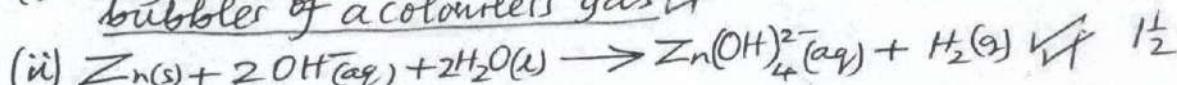


Milk of lime or calcium hydroxide solution is added to the mixture to precipitate the hydroxides of other elements (e.g. Al or Fe etc.) and mixture filtered.

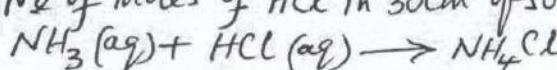
The filtrate is acidified and using zinc sulphate and electrolysed using aluminium cathode and lead anode. Pure zinc forms at the cathode.



(d) (i) Grey solid dissolves to form a colourless solution and bubbles of a colourless gas is



$$(e) \text{No of moles of HCl in } 30\text{cm}^3 \text{ of soln} = \frac{0.062 \times 30}{1000} = 1.86 \times 10^{-3}$$



$$[\text{NH}_3] \text{ in organic layer} = \frac{1.86 \times 10^{-3} \times 1000}{50} = 0.0372 \text{ M}$$

$$K_D = \frac{[\text{NH}_3] \text{ free in aqueous layer}}{[\text{NH}_3] \text{ free in organic layer}}$$

06

$$\Rightarrow [\text{NH}_3] \text{ free in aq. layer} = 25.0 \times 0.0372 = 0.93 \text{ M}$$

$$\text{No of moles of HCl in } 40\text{cm}^3 \text{ of soln} = \frac{0.5 \times 40}{1000} = 2 \times 10^{-2}$$

$$[\text{NH}_3]_{\text{total}} \text{ in aq. layer} = \frac{2 \times 10^{-2} \times 1000}{20} = 1 \text{ M}$$

$$[\text{NH}_3]_{\text{complexed}} = 1 - 0.93 = 0.07 \text{ M}$$

$$\frac{[\text{NH}_3]_{\text{complexed}}}{[\text{Zn}^{2+}]} = 4; [\text{Zn}^{2+}] = \frac{0.07}{4} = 0.0175 \text{ M}$$

$$\text{Mass of Zn in ore} = (0.0175 \times 65.7) = 1.1498 \text{ g}$$

$$\% \text{ of Zn in ore} = \left(\frac{1.1498}{1.5} \times 100 \right) \% = 76.65 \%$$

(f) - To galvanise iron
- To make alloys

01/2

BUGANDA MOCKS 2023

DRAFT GUIDE CHEMISTRY PS25/3

I. You are provided with the following;

FA1; which is a solution containing 11.2 g l^{-1} of thiosulphate ions, $\text{S}_2\text{O}_3^{2-}$

FA2; which is a solution containing approximately 0.02M Manganate (VII) ions

Solid T; which is a salt containing iron (II) ions.

1M sulphuric acid

Starch indicator

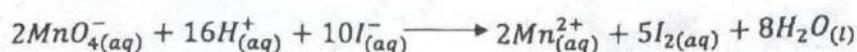
0.5M potassium iodide solution

You are required to;

(i) Standardise FA2 using FA1

(ii) Determine the percentage by mass of iron in T

In acidic medium, Manganate (VII) ions react with iodide ions to liberate iodine according to the equation



The iodine liberated reacts with thiosulphate ions according to the following equation



Manganate (VII) ions react with Iron (II) ions according to the following equation.



Procedure; PART A

(a) Pipette 25.0 cm^3 (Or 20 cm^3) of FA2 into a conical flask and add an equal volume of 1M sulphuric acid using a measuring cylinder, followed by 10 cm^3 of 0.5M potassium iodide solution.

Titrate the iodine liberated with FA1 using starch indicator. Repeat the titration until you obtain consistent results.

Record your results in table I below

Volume of pipette used 25.00 / 25.0 / 25 \checkmark must be indicated cm 3 ($\frac{1}{2}$ mk)

OK

Table I

Final burette reading (cm 3)	27.00	25.80	26.80
Initial burette reading (cm 3)	2.00	1.00	2.00
Volume of FA1 used (cm 3)	25.00 \checkmark	24.80 \checkmark	24.80 \checkmark

04L

$$\text{CR/TR} = \pm 5 (29.80 - 29.80)$$

\checkmark Deny $1\frac{1}{2}$ mks for any column out of the centre range (GR)

\checkmark All entries must be 2 dps and 0-50

\checkmark FBR > IBR

State the volumes of FA1 used to calculate the average volume
 24.80 and 24.80 agree ± 0.1 and within the CR
 (1/2 mks)

Calculate the average volume of FA1

(3 1/2 mks)

$$\frac{24.80 + 24.80}{2} = 24.80 \pm 0.1 \text{ M.M.}$$

± 0.2
 ± 0.3
 ± 0.4
 ± 0.5

should be within the CR

Questions

(a) Rfm of $S_2O_3^{2-} = 2(32) + 3(16) = 112$
 112 g of $S_2O_3^{2-}$ weigh contain 1 mole ✓
 11.2 g of $S_2O_3^{2-}$ contain $\frac{11.2}{112}$ moles ✓
 $= 0.1 \text{ M}$ ✓

1000 cm³ of solution contain 0.1 moles of $S_2O_3^{2-}$ const ✓
 24.800 cm³ of II II $\left(\frac{0.1 \times 24.80}{1000}\right)$ moles of $S_2O_3^{2-}$ ions
 $= 2.48 \times 10^{-3}$ moles

(b) 2 moles of $S_2O_3^{2-}$ react with 1 mole of I_2 liberated
 2.48 $\times 10^{-3}$ moles of $S_2O_3^{2-}$ react with $\left(\frac{2.48 \times 10^{-3}}{2}\right)$ moles of I_2 liberated.
 $= 1.24 \times 10^{-3}$ moles

5 moles of I_2 are liberated by 2 moles of MnO_4^- ions Q3
 1.24 $\times 10^{-3}$ moles of I_2 are liberated by $\left(\frac{2 \times 1.24 \times 10^{-3}}{5}\right)$ moles of MnO_4^- ions

25.00 cm³ of solution contain 4.96×10^{-4} moles of MnO_4^- ions
 1000 cm³ of II II $\left(\frac{4.96 \times 10^{-4} \times 1000}{25.0}\right)$ moles of MnO_4^- ions
 $= 0.0198 \text{ M}$ ✓

alternatively:

5 moles of $S_2O_3^{2-}$ react with 1 mole of MnO_4^-
 2.48 $\times 10^{-3}$ moles of $S_2O_3^{2-}$ react with $\left(\frac{2.48 \times 10^{-3}}{5}\right)$ moles of MnO_4^-
 $= 4.96 \times 10^{-4}$ moles

25.0 cm³ of solution contain 4.96×10^{-4} moles of MnO_4^- ions
 1000 cm³ of II II $\left(\frac{4.96 \times 10^{-4} \times 1000}{25.0}\right)$ moles of MnO_4^- ions
 $= 0.0198 \text{ M}$ ✓



Procedure; PART B

- (a) Weigh accurately 5.0g of T. Dissolve it in a minimum amount of distilled water and transfer the solution into a 250 cm^3 volumetric flask. Make the solution up to the mark with distilled waste and label it FA3.
- (b) Pipette 25.0cm^3 (or 20.0cm^3) of FA3 into a conical flask and add an equal volume of 1M sulphuric acid. Titrate the solution with FA2 from the burette. Repeat the titration until you obtain consistent results.

Record your results in table II below

RESULTS;

Mass of weighing bottle + T = 6.00 g ($\frac{1}{2}$ mk)

Mass of empty weighing bottle = 1.00 g ($\frac{1}{2}$ mk)

Mass of T used = 5.00 g ($\frac{1}{2}$ mk)

Volume of pipette used = $25.00/25.0$ cm^3 ($\frac{1}{2}$ mk) as in part I

(62)

TABLE II

Final burette reading (cm^3)	14.90	27.60	40.30
Initial burette reading (cm^3)	2.00	14.90	27.60
Volume of FA2 used (cm^3)	12.90 ✓	12.70 ✓	12.70 ✓

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

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

(51)

State volumes of FA2 used to calculate the average volume;

..... 12.70 and 12.70 (agree ± 0.1) ✓

Calculate the average volume of FA2

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

$$\frac{12.70 + 12.70}{2} = 12.70 \pm 0.1 \text{ cm}^3$$

± 0.2

± 0.3

± 0.4

± 0.5

(03)

Weighing

- ✓ At least 1dp or else deny marks
- ✓ mass of T + empty bottle > mass of empty bottle
- ✓ Deny marks for mass of empty bottle equal to zero
- ✓ Range of weighed mass of T; can be from ~~4.9~~ $(4.9 - 5.1)$ g

(0)

C (i) ~~1000 cm³ of FA2 contain 0.0198 moles of MnO₄⁻ ions~~ ✓ from Part I/
 12.70 cm³ of FA2 contain $\frac{(0.0198 \times 12.70)}{1000}$ moles of MnO₄⁻ ions
 0.32

$$= 2.5146 \times 10^{-4} \text{ moles of MnO}_4^-$$

1 mole of MnO₄⁻ ions reacts with 5 moles of Fe²⁺ ions
 2.5146 × 10⁻⁴ moles of MnO₄⁻ ions react with $(5 \times 2.5146 \times 10^{-4})$ moles of Fe²⁺

$$= 1.2573 \times 10^{-3} \text{ moles of Fe}^{2+}$$

25 cm³ of FA3 contain 1.2573×10^{-3} moles of Fe²⁺ ions

1000 cm³ of FA3 contain $\frac{(1.2573 \times 10^{-3} \times 1000)}{25}$ moles of Fe²⁺ ions

$$= 0.050292 \text{ mol l}^{-1}$$

$$\text{or } = 0.05 \text{ mol l}^{-1}$$

(rounding off must be done at the last step)

(ii) 1000 cm³ of FA3 contain 0.05 moles of Fe²⁺ ions
 250 cm³ of FA3 " $\frac{(0.05 \times 250)}{1000}$ moles of Fe²⁺ ions

$$= 0.0125 \text{ moles of Fe}^{2+}$$

$$\therefore \text{No of moles of Fe in T} = 0.0125$$

$$1 \text{ mole of Fe weighs } 56 \text{ g}$$

$$0.0125 \text{ moles of Fe weighs } (56 \times 0.0125) \text{ g}$$

$$= 0.7$$

$$\% \text{ of Fe in T} = \left(\frac{0.7}{5.0} \times 100 \right) \% = 14\%$$

accept: 250 cm³ of solution contain 5 g of T

$$1000 \text{ cm}^3 \text{ of " " } \frac{(5 \times 4000)}{250} \text{ g of T}$$

$$= 20 \text{ g of T}$$

$$\text{No of moles of Fe in 1 litre of T} = 0.05$$

$$1 \text{ mole of Fe weighs } 56 \text{ g}$$

$$0.05 \text{ moles of Fe weighs } (56 \times 0.05) \text{ g} = 2.8 \text{ g}$$

$$\% \text{ of Fe in T} = \left(\frac{2.8}{20} \times 100 \right) \% = 14\%$$

QN 2

(a)	<ul style="list-style-type: none"> • Colourless condensate/liquid turns white anhydrous CuSO_4 blue ✓ • Colourless gas turns moist blue litmus paper red and limewater milky. ✓ • Colourless gas/vapour with a sweet smell, forms a yellow ppt. with Brady's reagent. ✓ • Yellow solid residue when hot and white on cooling ✓ 	hydrated salt or water of crystalisation $\text{CO}_2(\text{g})$; $\text{CO}_3^{2-}/\text{HCO}_3^-$ $\text{CO}_4^{2-}/\text{CH}_3\text{COO}^-$ $(\text{CH}_3)_2\text{CO}(\text{g})$; CH_3CO_5^- (25 max)
(b)	<ul style="list-style-type: none"> • Effervescence occurs • Misty fumes with a vinegar smell turns moist blue litmus red. ✓ 	$\text{CH}_3\text{COOH}(\text{g})$ CH_3COO^- (1½ max)
(c)	Colourless solution ✓	Ca^{2+} , Mg^{2+} , Ba^{2+} , Al^{3+} , NH_4^+ , Pb^{2+} , Zn^{2+} present 1½
(d)	Reddish-brown (or brown) ppt on boiling	CH_3COO^- ✓ 01
(e)	Sweet fruity smell evolved /detected	Esterification CH_3COO^- 1½
(f)	White ppt insoluble turns brown Dirty white/brown residue ✓ Colourless filtrate ✓	Probably Mn^{2+} Mn^{2+} in residue Al^{3+} , Zn^{2+} , Pb^{2+} in filtrate 3½

(g) To the filtrate from (f), add dilute nitric acid to acidify. Then divide the acidified filtrate into five parts.	White ppt Soluble in acid.	Probably Al^{3+} or Zn^{2+} or Pb^{2+} or Sn^{2+} or Sn^{4+}
(i) to the first part of the acidified filtrate, add sodium hydroxide dropwise until in excess	White ppt Soluble in excess giving a colourless solution	Probably Al^{3+} or Zn^{2+} or Pb^{2+} or Sn^{2+} or Sn^{4+}
(ii) To the second part of the acidified filtrate add dilute ammonia solution dropwise until in excess.	White ppt Soluble in excess giving a colourless solution	Probably Zn^{2+} present
(iii) Use the third part of the acidified filtrate to carry out a test of your own to confirm one of the cations in Q. Record test and observations.	White ppt Soluble in excess.	Zn^{2+} present. 02
Test: $\text{NH}_4\text{Cl}_{(s)} + \text{Na}_3\text{HPO}_4_{(s)} + \text{NH}_3_{(\text{excess})}$		
(iv) To the fourth part of the acidified filtrate, add 4 – 5 drops of Lead (II) nitrate solution and heat gently.	White ppt insoluble on heating	SO_4^{2-} present. 1½
(v) Use the fifth part of the acidified filtrate to carry out a test of your own choice to confirm the second ion in Q. Record test and observations.	White ppt	SO_4^{2-} present 1½
Test: Add $\text{Ba}(\text{NO}_3)_2$ or BaCl_2	Colourless Solution answ: Pale brown	Probably Mn^{2+} present. 01
(h) Wash the residue from (f) and dissolve it into dilute nitric acid. Divide the acid solution into three parts.		

10½

(i) To the first part of the acidic solution, add dilute sodium hydroxide dropwise until in excess.	White ppt insoluble in excess turns brown on standing or Dirty white ppt insoluble in excess	Probably Mn^{2+} 02
(ii) To the second part of the acidic solution, add dilute ammonia solution dropwise until in excess.	White ppt insoluble in excess turns brown on standing or Dirty white ppt insoluble in excess	Probably Mn^{2+} 02
(iii) Use the third part of the acidic solution to carry out a test of your own to confirm. One of the cations in Q. Record test and observations.	Purple/pink coloration (solution)	Mn^{2+} ✓ 1/2

Record test and observations.

Test: Add 2-3 drops conc HNO_3 +

Solid sodium bismuthate

or conc HNO_3 + PbO_2 + heat

(j) Identify the

g(III)

(i) Cations in Q Zn^{2+} g(III) and (d) or (e)

(ii) Anion in Q CH_3COO^- (d) or (e) and SO_4^{2-} g(V)

g(IV)

g(V)

02

7½

3. You are provided with substance W which is an organic compound. You are required to determine the nature and functional group in W. Carry out the following tests on W and record your observations and deductions in the table below.

TESTS	OBSERVATIONS	DEDUCTIONS
(a) Burn a small amount of W on a spatula end	Colourless liquid burns with a yellow sooty flame	Aromatic Cpd (or) Aliphatic Unsaturated Cpd with a high carbon content
(b) To 0.5cm^3 of W in a test tube add 1cm^3 of water, shake and leave to stand. Test with litmus paper	Immiscible Minstube No effect on both blue and red litmus	Non-polar Cpd of high molecular mass Neutral Cpd Probably alcohol, Carbonyl ester Cpd
(c) To 1cm^3 of W, add an equal volume of methanol. Shake and divide the resultant mixture into two parts.	Soluble in methanol	Ignare
(i) To the first part of the mixture in (c), add 4 - 5 drops of sodium carbonate solution	No effervescence / bubbles of gas	Carboxyl gp absent Or Carboxylic acid absent
(ii) To the second part of the mixture in (c), add 5 drops of neutral Iron (III) chloride solution	No purple colouration	Phenol absent
(d) To 1cm^3 of W, add 2, 4 - dinitrophenyl hydrazine dropwise until in excess. Shake the mixture.	Yellow (w Orange) ppt	Carbonyl Cpd Result Or Aldehydes and Ketones present

(e) To 1cm ³ of W, add 2cm ³ of acidified potassium dichromate solution and heat the mixture.	No observable change	reducing agent present Aldohyde absent ∴ Alcohol present reject; reducing agent absent
(f) To 1cm ³ of W, add in about 1cm ³ of methanol. To the solution, add 4cm ³ of iodine solution followed by sodium hydroxide solution dropwise until the solution is pale yellow. Heat the mixture and allow to stand	Yellow ppt	Amidic group Ketone of $\text{C}_6\text{H}_5\text{C}_2\text{H}_5$ structure Present

(g) Comment on the nature of W;
Amidic Ketone with $\text{C}_6\text{H}_5\text{C}_2\text{H}_5$ structure
 present

16