

UACE P525/2 CHEMISTRY
 PROPOSED MARKING GUIDE
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QN1.

(a) (i) Elements
moles

$$\frac{87.8}{12}$$

$$\frac{12.2}{1} \quad \checkmark$$

$$7.31667$$

$$12.2$$

simpllest ratio

$$\frac{7.31667}{7.31667}$$

$$\frac{12.2}{7.31667} \quad \checkmark$$

$$(1 : 1.667)^3 \quad \checkmark$$

$$3 : 5 \quad \checkmark$$

Empirical formula is C_3H_5 \checkmark 3

reject C_6H_{10}
and deny
marks
afterwards.

(ii)

$$(C_3H_5)_n = 41 \times 2 \quad \checkmark$$

$$[(3 \times 12) + (5 \times 1)]n = 82 \quad \checkmark$$

$$41n = 82$$

$$n = 2 \quad \checkmark$$

Molecular formula is C_6H_{10} \checkmark

2½

b(i)

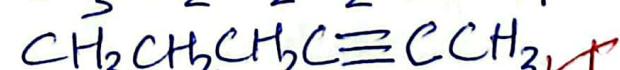


①

(ii) Hex-1-yne



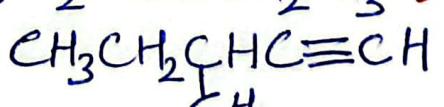
Hex-2-yne



Hex-3-yne



3-methylpent-1-yne



③

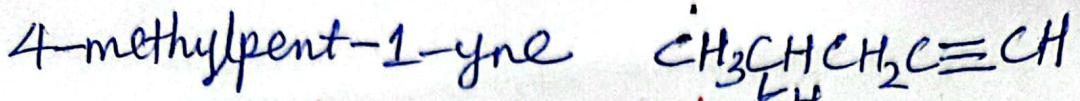
3,3-dimethylbut-1-yne



4-methylpent-2-yne



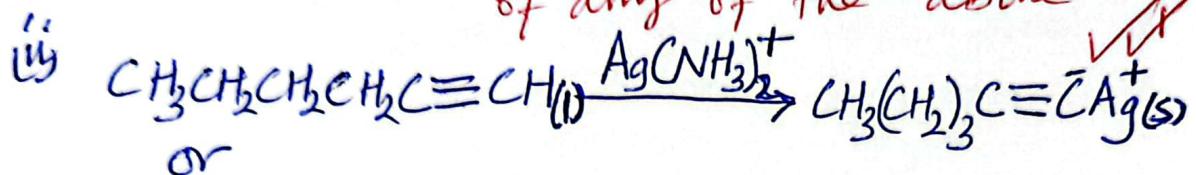
①



- Accept any correct CH_3
- ignore extra answers if correct
- names of branched isomers should strictly be one word (no - nates)

(c) i) Hex-1-yne or 3-methylpent-1-yne or 3,3-dimethylbut-1-yne or 4-methylpent-1-yne

Accept structural formula of any of the above.



or

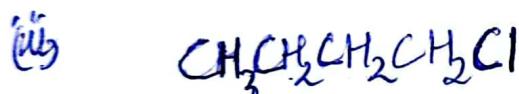
15



or



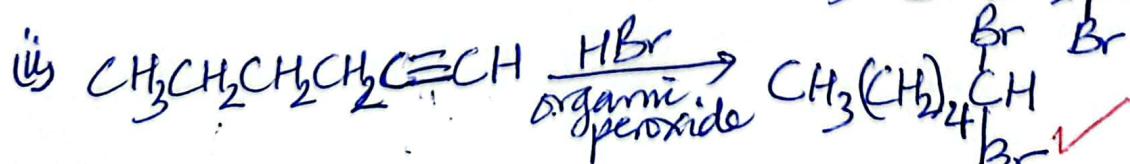
Accept eqn not for any terminal alkyne in
Cl(i)



Accept any longer, but correct routes

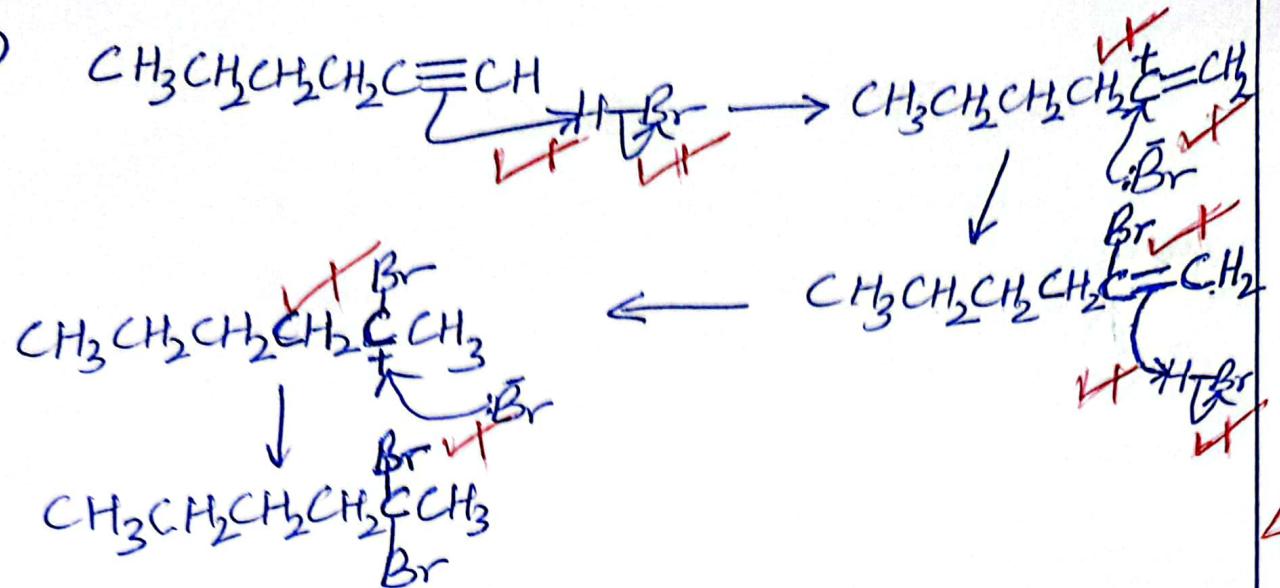
16

reject synthesis through



2)

(e)



——————
20

45

(3)

Qn 2

emphasize

(a) (i) When a mixture of two immiscible liquids is heated at a given temperature, each of the liquids exerts its own vapour pressure independently such that the total vapour pressure above the mixture is the sum of the vapour pressures of the two pure liquids at that temperature. On continued heating, both the vapour pressure of each liquid and the total vapour pressure above the mixture increases. The mixture therefore boils when the total vapour pressure is equal to the external/atmospheric pressure at a temperature below the boiling points of the two liquids taken separately.

5

(ii) It purifies substances that decompose at temperatures near their normal boiling points. → for @ extraneous. It purifies liquids which boil at too high temperatures.

2

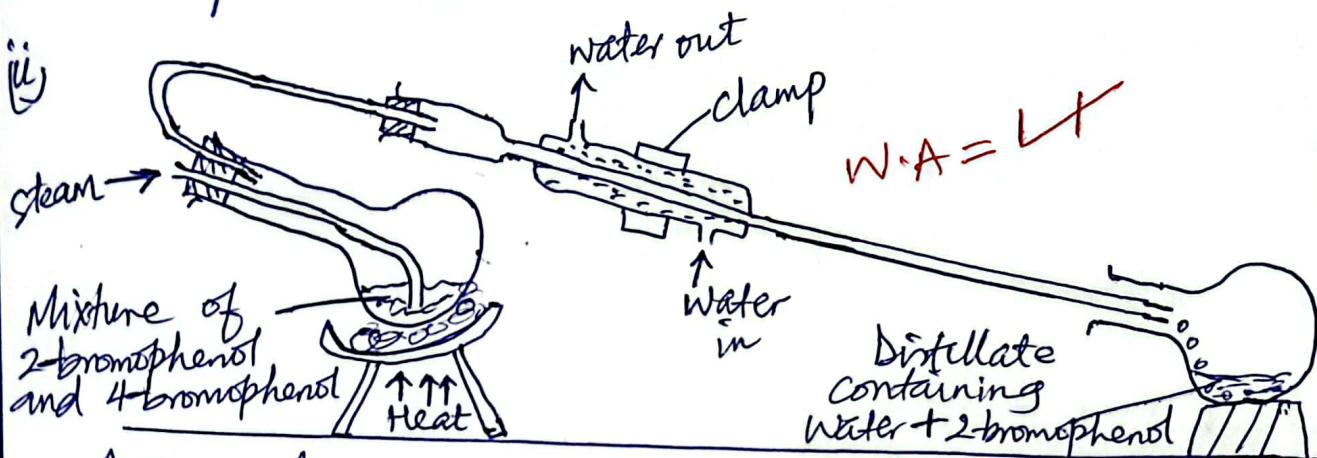
$$(b) \frac{P_{H_2O}}{P_{H_2O}} = \frac{n_{H_2O}}{n_{H_2O}} \quad \begin{matrix} \checkmark \\ \text{Accept alternative correct formulae} \end{matrix}$$

$$\frac{(1300 - 87000)}{87000} = \left(\frac{bs}{RFM + Q} \right) \div \left(\frac{100 - bs}{18} \right) \quad \begin{matrix} \checkmark \\ \text{substitution} \end{matrix}$$

4

$$RFM + Q = \frac{65 \times 18 \times 87000}{14300 \times 35} = \underline{203.38} \quad \begin{matrix} \checkmark \\ \text{reject answer with units} \end{matrix}$$

Q) The lone pairs of electrons on the oxygen atom interact with the delocalised π -electrons of the benzene ring activating it and preferentially stabilizing products at the 2- and 4-positions hence favouring electrophilic aromatic substitution at those positions - (4)



- Apparatus is set up as shown above.
- The mixture is heated and steam is passed through the mixture from a steam generator.
- At a temperature below 100°C and 1 atm, a mixture of water and the more volatile 2-bromophenol is collected as distillate in the receiver.
- The distillate is then shaken with ether in a separating funnel and the two layers separated. Accept any other correct method of separation.
- The organic layer is purified by distillation to obtain 2-bromophenol ✓ (5)

QN 3

(a) Atomic radius generally increases from carbon to lead. This is because from one element to another, nuclear charge increases because protons are added to the nucleus. Screening effect also increases and an extra energy level completely filled with electrons is added. However, increase in screening effect outweighs increase in nuclear charge hence effective nuclear charge increases and the outermost electrons are far increasingly far and weakly attracted to the nucleus.

2

Melting point generally decreases from carbon to lead. Accept down the group reject any other trend. This is because carbon, silicon and hence germanium have giant molecular structures with covalent bonds between atoms whose strength decrease with increase in atomic radius, increasing the bond length.

Tin and lead have giant metallic structures with metallic bonds between atoms that are relatively weaker than covalent bonds due to increasing atomic radius.

31
32

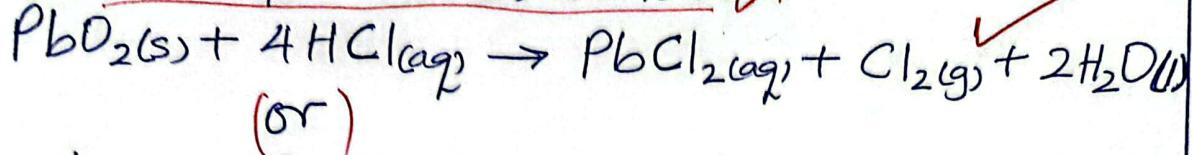
(b) +2 oxidation state stability increases from carbon to lead compounds while +4 oxidation state stability decreases due to inert pair effect which increases with increase in atomic radius.

21
22

reject +2 oxidation state increases emphasize stability.

6)

① (i) Lead(IV) oxide either oxidises hot concentrated hydrochloric acid to chlorine and itself reduced to lead(II) chloride.

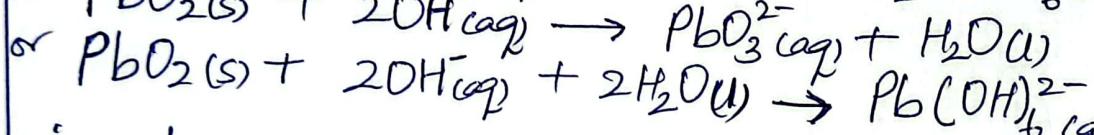
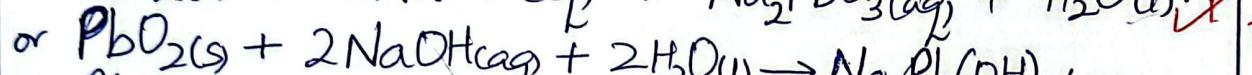
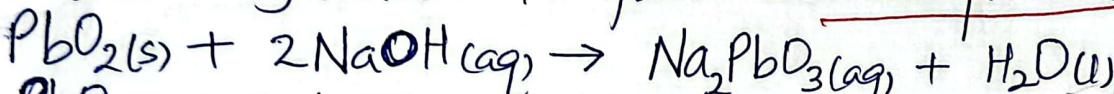


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Lead(IV) oxide being amphoteric reacts with cold concentrated hydrochloric acid to form lead(IV) chloride and water.



(ii) Lead(IV) oxide is amphoteric hence reacts with basic hot concentrated sodium hydroxide to form sodium plumbate(IV).



2

Q2

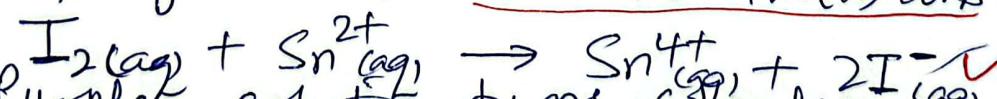
i) Observation:

Yellow/brown solution turns green
Tin(II) ions reduce iron(III) ions to iron(II) ions as they are oxidised to tin(IV) ions.



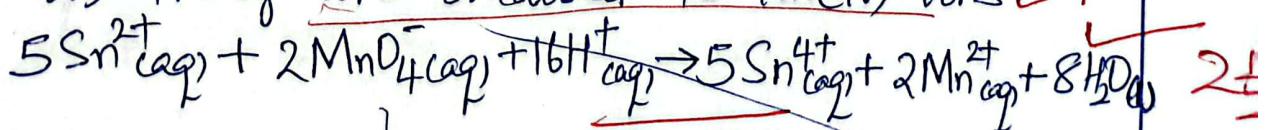
21

(ii) Brown solution turns colourless
Tin(II) ions reduce iodine to iodide ions as they are oxidised to tin(IV) ions.



21

(iii) Purple solution turns colourless
Tin(II) ions in acidic medium reduce manganese(VII) ions to manganese(II) ions as they are oxidised to tin(IV) ions.



21

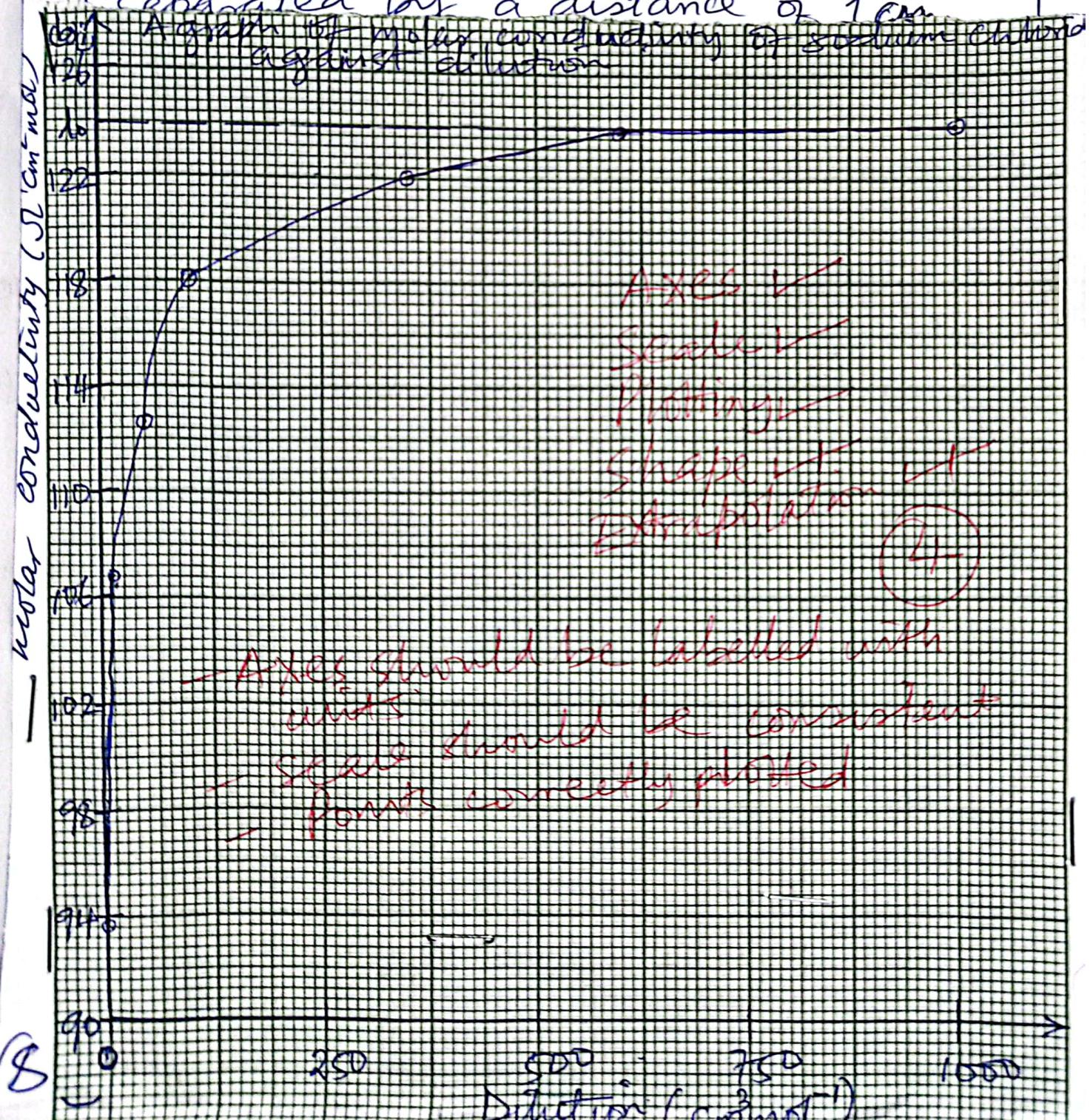
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Qn 4

(a) The electrolytic conductivity divided by concentration of an electrolyte solution. ✓ 2
or

The conductance of a solution containing 1 mole of an electrolyte placed between two parallel electrodes, each of cross-sectional area 1 cm^2 and separated by a distance of 1 cm.



iii) Molar conductivity increases with increase in dilution to a maximum value at which it remains (almost) constant no matter how much the dilution is increased. Sodium chloride is a strong electrolyte. As dilution increases, inter-ionic distance increases, ionic interference reduces and ionic mobility increases.

At zero concentration, ionic interference is negligible making molar conductivity (almost) constant at a maximum value.

4/2

iii)

$$124 \Omega^{-1} \text{cm}^2 \text{mol}^{-1}$$

iv)

$$\text{Dilution, } V = \frac{1}{c} = \frac{1}{0.01} = 100 \text{ cm}^3 \text{mol}^{-1}$$

$$\Lambda_v = k\alpha = 118 \Omega^{-1} \text{cm}^{-1} \quad \text{(i)}$$

At infinite dilution, $\Lambda_{\infty} = k$, since $\alpha = 1$

$$\therefore \Lambda_{\infty} = 124 = k \quad \text{(ii)}$$

$$\text{(i)} \div \text{(ii)} \Rightarrow \frac{\Lambda_v}{\Lambda_{\infty}} = \frac{k\alpha}{k} = \frac{118}{124} = 0.952$$

$$\alpha = 0.952$$

or;

$$\Lambda_c = \frac{1000 \times \Lambda}{c} = \frac{1000 \times 118 \times 10^{-3}}{0.01} = 118 \Omega^{-1} \text{cm}^{-1}$$

$$\alpha = \frac{\Lambda_c}{\Lambda_{\infty}} = \frac{118}{124} = 0.952$$

Q) i) Increase in temperature increases the molar conductivity because the average kinetic energy of conducting ions increases, viscosity of water decreases and ionic mobility increases.

1/2

3

2

2)

(ii) For a weak electrolyte, the effect of temperature depends on the enthalpy change that accompanies ionisation. For a weak electrolyte that ionises exothermically, increase in temperature decreases the degree of dissociation, reducing the number of conducting ions and decreasing molar conductivity. For a weak electrolyte that ionises endothermically, increase in temperature increases the degree of dissociation, increasing the number of conducting ions and increasing molar conductivity. (4)

20

(10)

Qn5

emphasize key words.

(a) (i) The product of molar concentrations of ions of a sparingly soluble electrolyte/ionic compound in its saturated solution raised to appropriate powers at a given temperature ①

(ii) Increase in temperature increases the value of solubility product for an electrolyte that dissociates endothermically ②

Increase in temperature decreases the value of solubility product for an electrolyte that dissociates exothermically.

- (iii)
- precipitation of metallic hydroxides.
 - precipitation of sulphides. ①
 - precipitation of chlorides. Accept any 2
 - salting out of soap. -1/2 for each extra wrong
 - purification of common salt.

(b) Excess calcium iodate(V) is added to a given volume of distilled water in a container.

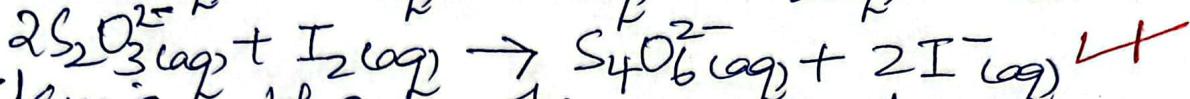
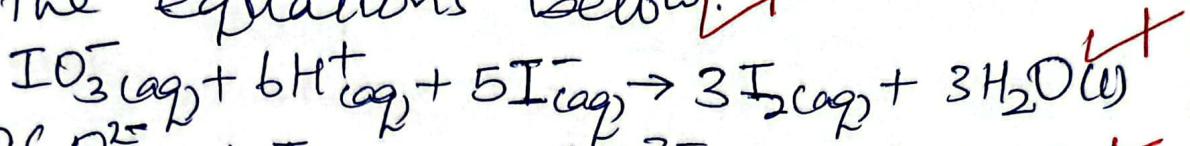
The mixture is shaken for sometime and then allowed to settle at a fixed temperature to attain equilibrium.

The mixture is filtered to obtain a saturated solution of calcium iodate(V).

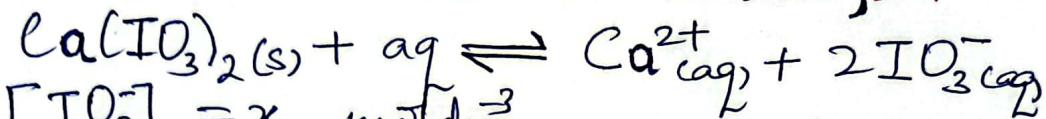
A known volume of the saturated solution is pipetted into a conical flask and a known volume of potassium iodide is added and then acidified with a known volume of sulphuric acid to liberate iodine.

The liberated iodine is titrated with a standard solution of sodium thiosulphate (using starch indicator).

The molar concentration of iodate(V) ions is calculated using the stoichiometry of the equations below:



Taking the molar concentration of iodate(V) ions to be x mol dm⁻³,



$$[\text{IO}_3^-] = x \text{ mol dm}^{-3}$$

$$[\text{Ca}^{2+}] = \frac{1}{2}[\text{IO}_3^-] = \frac{1}{2}x \text{ mol dm}^{-3}$$

$$K_{sp} = [\text{Ca}^{2+}][\text{IO}_3^-]^2 = \left(\frac{1}{2}x\right)(x)^2 = \frac{1}{2}x^3 \text{ mol}^3 \text{ dm}^{-9}$$

(Alternatively;

Excess calcium iodate(V) is added to a given volume of distilled water in a container and the mixture shaken for sometime and allowed to settle at a fixed temperature to attain equilibrium. The mixture is filtered to obtain a saturated solution of calcium iodate(V). The electrolytic conductivity of the saturated solution, $\kappa_{solution} (\Omega^{-1} \text{cm}^{-1})$ is measured using a conductivity meter.

The electrolytic conductivity of water, $\kappa_{water} (\Omega^{-1} \text{cm}^{-1})$ at the same temperature is obtained from books.

Also, the molar conductivities at infinite dilution (Λ_0) of calcium ions and iodate(V) ions are read from the tables.

Treatment of results;

The electrolytic conductivity of calcium iodate is obtained by:

$$\kappa_{\text{Ca}(\text{IO}_3)_2} = \kappa_{\text{solution}} - \kappa_{\text{water}}$$

12

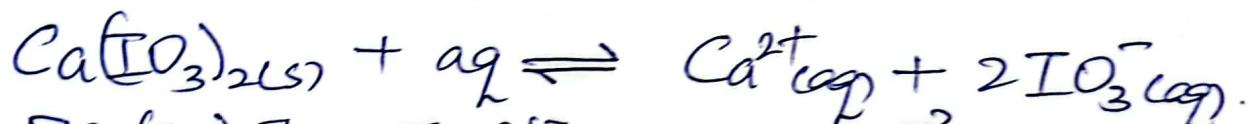
The molar conductivity of calcium iodate at infinite dilution is obtained by;

$$\Lambda_0 \text{Ca}(\text{IO}_3)_2 = \Lambda_0 \text{Ca}^{2+} + 2\Lambda_0 \text{IO}_3^- \quad \checkmark$$

Assuming $\Lambda_0 \text{Ca}(\text{IO}_3)_2 = \Lambda_c \text{Ca}(\text{IO}_3)_2$

$$\Lambda_c \text{Ca}(\text{IO}_3)_2 = \frac{1000 \times \Lambda_0 \text{Ca}(\text{IO}_3)_2}{C}, \text{ where}$$

C is solubility of $\text{Ca}(\text{IO}_3)_2$ in mol dm^{-3} .



$$[\text{Ca}(\text{IO}_3)_2] = [\text{Ca}^{2+}] = C \text{ mol dm}^{-3}.$$

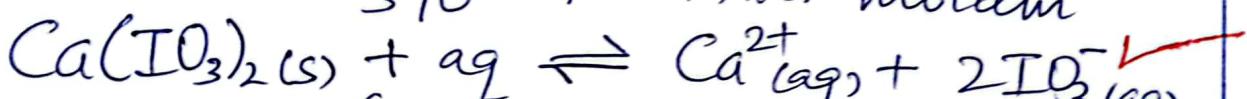
$$[\text{IO}_3^-] = 2[\text{Ca}(\text{IO}_3)_2] = 2C \text{ mol dm}^{-3}.$$

$$K_{sp} = [\text{Ca}^{2+}][\text{IO}_3^-]^2 = \frac{c \times (2c)^2}{2c^3} = \underline{\underline{2c^3 \text{ mol}^3 \text{ dm}^{-9}}}.$$

(7)

(e) (i) Molar mass of $\text{Ca}(\text{IO}_3)_2 = 40 + (2 \times 127) + (6 \times 16) \quad \checkmark$

$$[\text{Ca}(\text{IO}_3)_2] = \frac{3.08}{390} = 7.897 \times 10^{-3} \text{ mol dm}^{-3} \quad \checkmark$$



$$[\text{Ca}^{2+}] = [\text{Ca}(\text{IO}_3)_2] = 7.897 \times 10^{-3} \text{ M} \quad \checkmark$$

$$[\text{IO}_3^-] = 2[\text{Ca}^{2+}] = (2 \times 7.897 \times 10^{-3}) = 1.5794 \times 10^{-2} \text{ M}$$

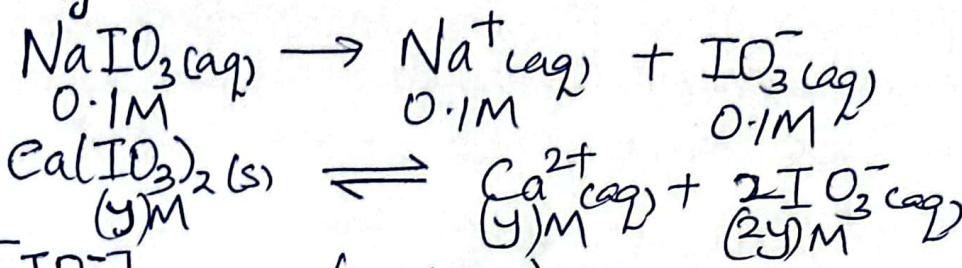
$$K_{sp} = [\text{Ca}^{2+}][\text{IO}_3^-]^2 = (7.897 \times 10^{-3})(1.5794 \times 10^{-2})^2 \quad \checkmark$$

$$= \underline{\underline{1.9699 \times 10^{-6} \text{ mol}^3 \text{ dm}^{-9}}}$$

ignore units

31

(ii) Let the solubility in 0.1M sodium iodate be y .



$$[\text{IO}_3^-]_{\text{total}} = (2y + 0.1)\text{M}.$$

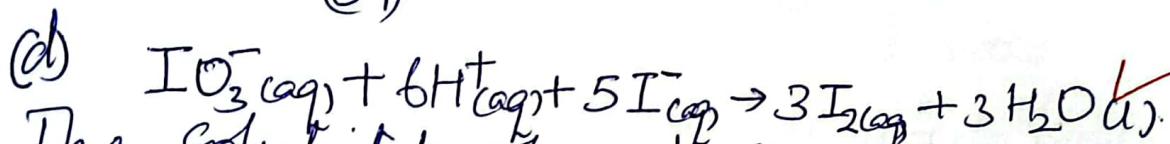
But since NaIO_3 is a strong electrolyte
 $0.1 >> 2y$ such that $2y + 0.1 \approx 0.1$.

$$\therefore [\text{IO}_3^-] \approx 0.1\text{M} \quad [\text{Ca}^{2+}] = y\text{M}.$$

$$K_{\text{sp}} = [\text{Ca}^{2+}][\text{IO}_3^-]^2 = y \times (0.1)^2 = 1.9699 \times 10^{-6}.$$

$$y = \frac{1.9699 \times 10^{-6}}{(0.1)^2} = 1.9699 \times 10^{-4} \text{ mol dm}^{-3}.$$

21



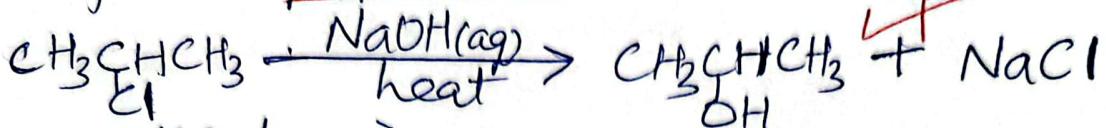
The solubility of calcium iodate(V) increases. This is because acidified potassium iodide reduces iodate(V) ions to iodine. This reduces the concentration of iodate(V) ions and more calcium iodate dissolves to restore equilibrium to maintain the value of equilibrium constant.

③

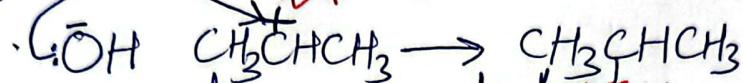
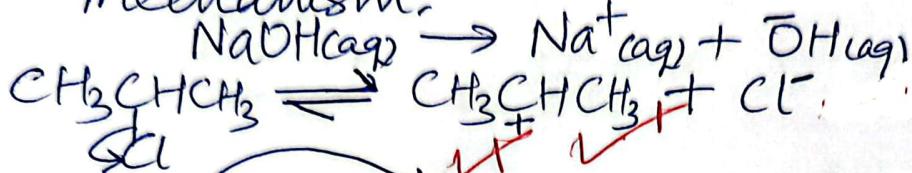
14

QN 6

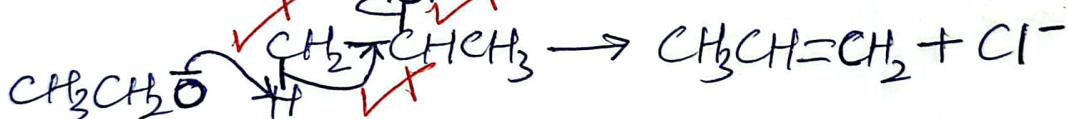
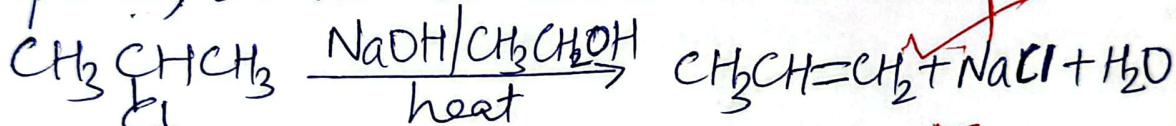
(a) 2-chloropropane reacts with aqueous sodium hydroxide solution on heating to form propan-2-ol and sodium chloride.



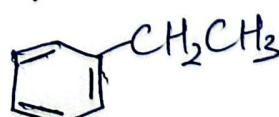
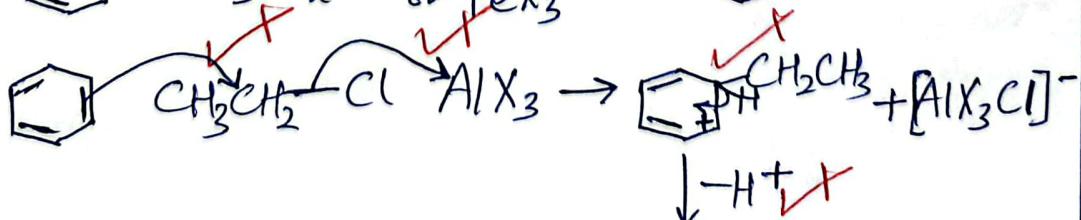
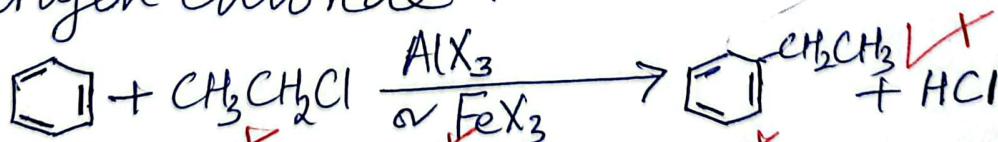
Mechanism:



2-chloropropane reacts with ~~also~~ ~~allohotol~~ ethanolic sodium hydroxide to form propene, sodium bromide and water.



↳ Benzene reacts with chloroethane in presence of anhydrous aluminium chloride/bromide catalyst or iron(III) chloride/bromide catalyst to form ethylbenzene and hydrogen chloride.



(15)

(F)

(4)

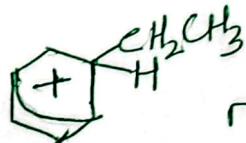
Alternatively;



Accept



reject



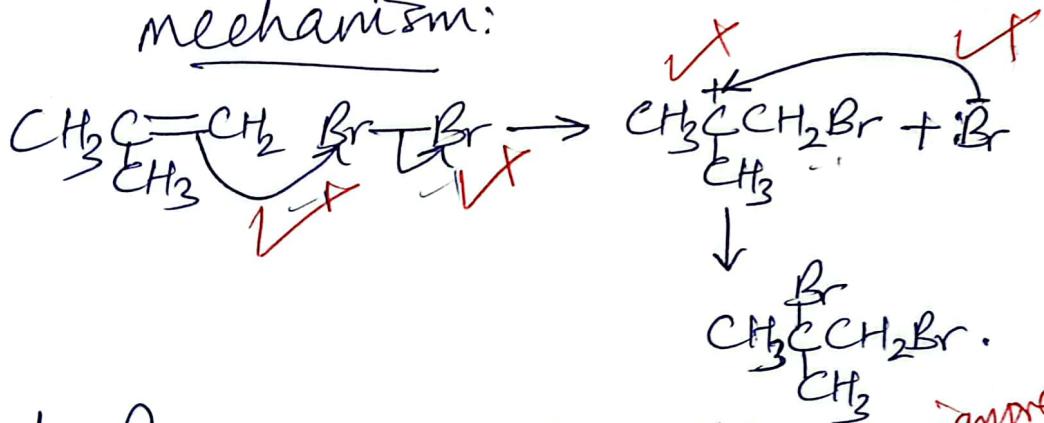
reject rings of
the kind
etc.



(c) 2-methylpropene reacts with bromine in tetrachloromethane to form 1,2-dibromo-2-methylpropene. *Emphasise correct IUPAC name.*

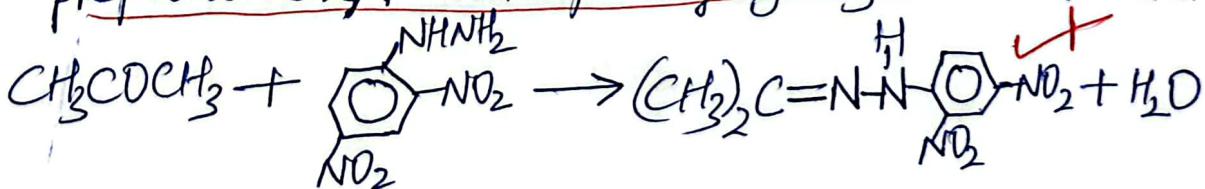


Mechanism:



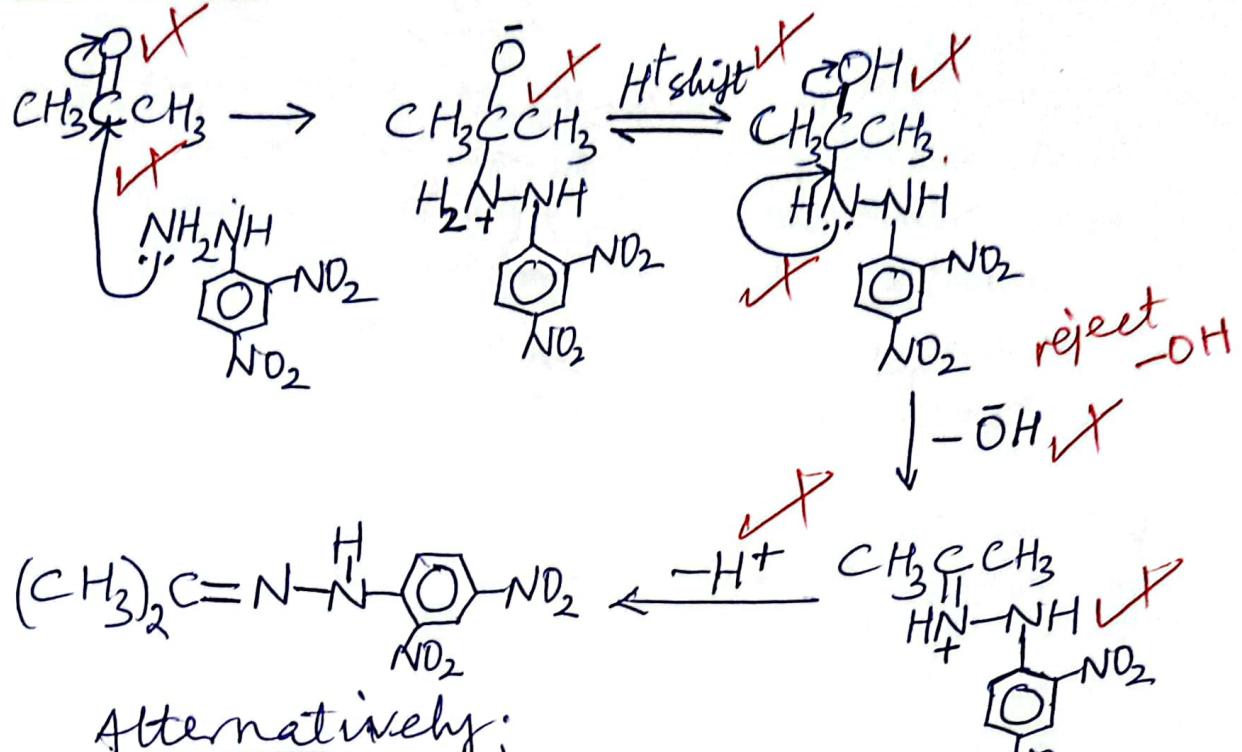
(3)

(d) Propanone reacts with 2,4-dinitrophenylhydrazine solution. *Ignore acidic medium. Emphasise correct IUPAC name.*

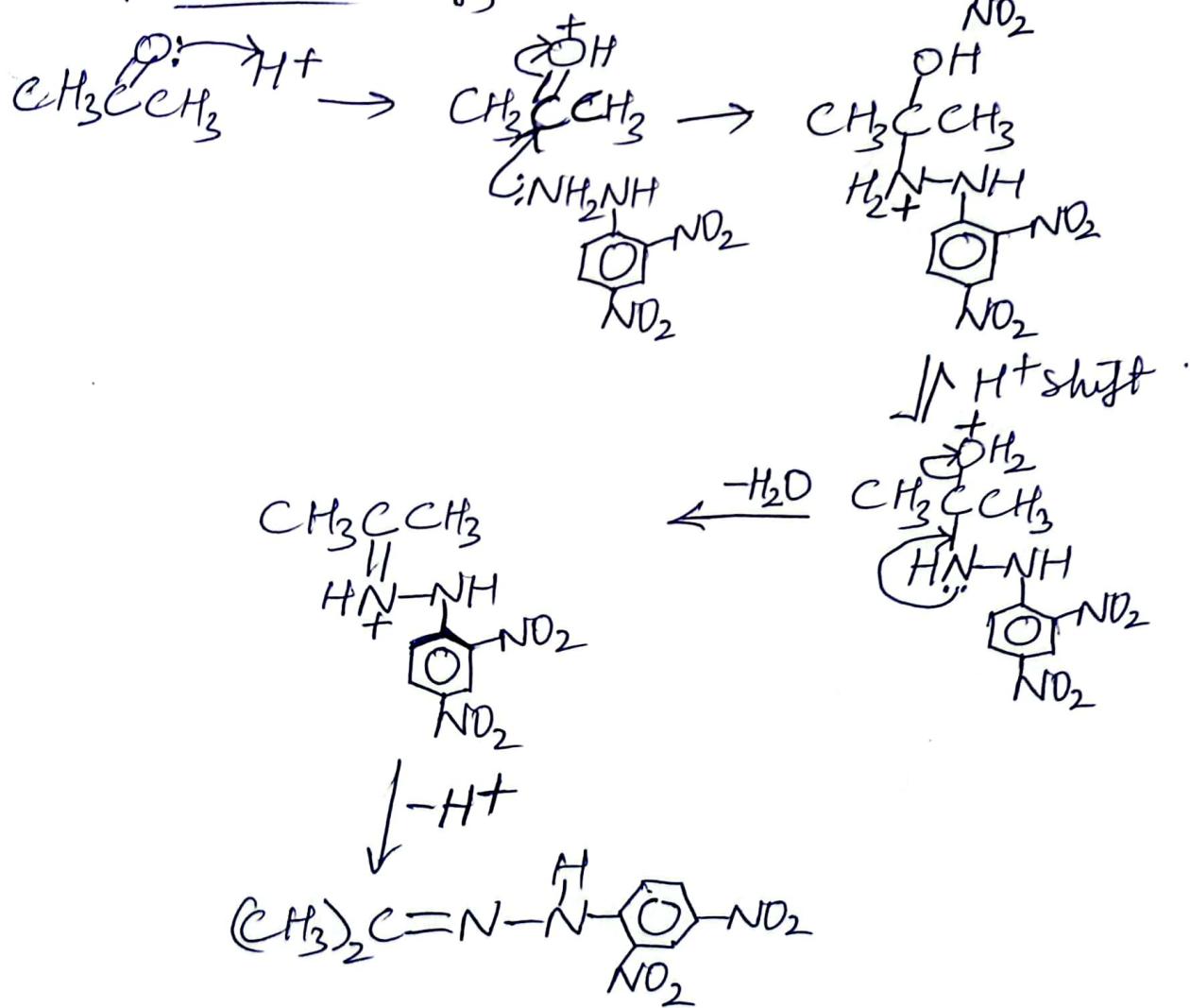


D)

Mechanism:



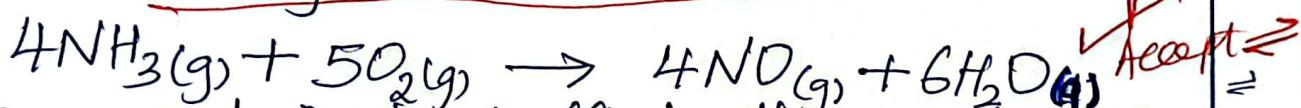
Alternatively;



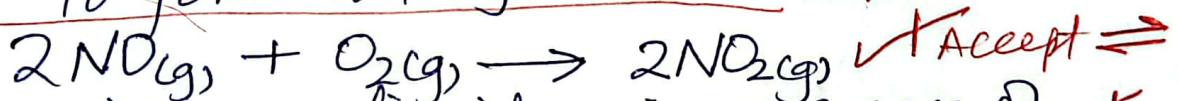
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Qn7

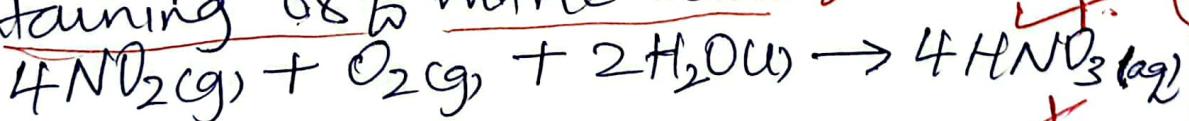
(a) Dry ammonia is mixed with excess dry dust free air and preheated. The mixture is then passed over red hot platinum-Rhodium gauze catalyst at about 900°C and 8 atmospheres to form nitrogen monoxide and water.



The reaction is sufficiently exothermic to maintain a temperature of 900°C . The gases formed are cooled rapidly and reacted with oxygen from excess air to form nitrogen dioxide.



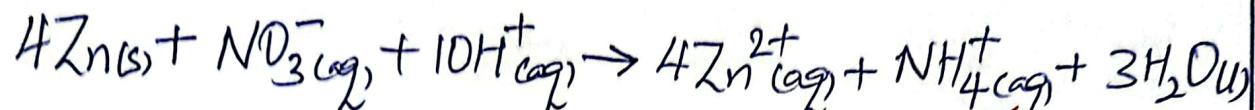
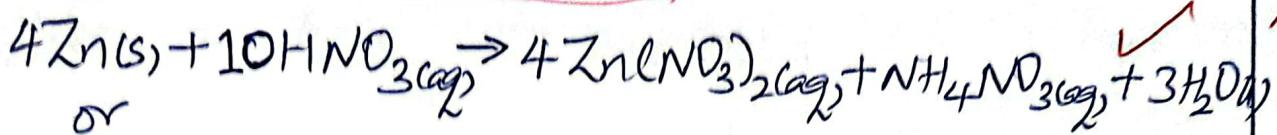
The nitrogen dioxide, in presence of more air, is absorbed in hot water in a steel absorption tower to form dilute nitric acid. The acid formed is distilled to form a constant boiling nitric acid mixture containing 68% nitric acid.



(b) The acid is slightly decomposed by heat to form brown fumes of nitrogen dioxide, which dissolve in it to form a yellow liquid.



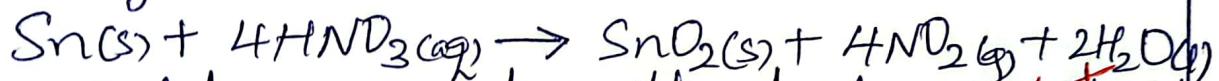
(ii) Zinc reacts with cold dilute nitric acid to form zinc nitrate, ammonium nitrate and water. X



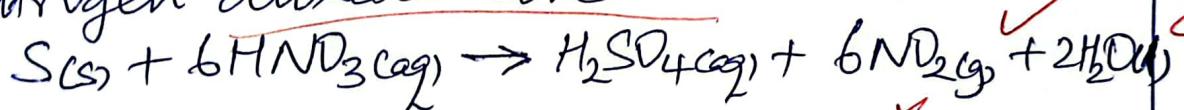
(iii) Tin reacts with cold dilute nitric acid to form tin(II) nitrate, ammonium nitrate and water. X



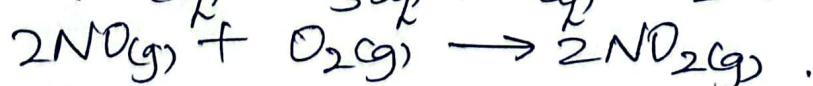
Alternatively; or
Tin also reacts with hot concentrated nitric acid to form tin(IV) oxide, nitrogen dioxide and water.



(iv) Sulphur reacts with hot concentrated nitric acid to form sulphuric acid, nitrogen dioxide and water. X



(d) (i) The pale green solution turns yellow/brown.
Hot concentrated nitric acid oxidises iron(II) ions to iron(III) ions with evolution of nitrogen monoxide. The nitrogen monoxide is oxidised by air to form brown fumes of nitrogen dioxide. X



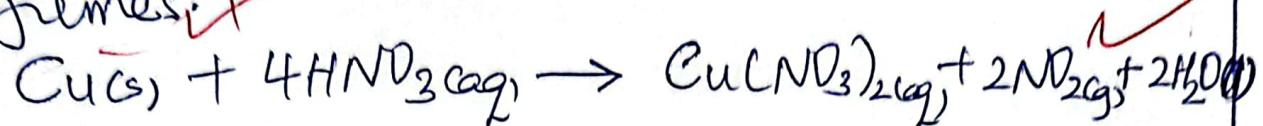
2

2

2

3

(ii) concentrated nitric acid oxidises copper to copper(II) nitrate and itself reduced to nitrogen dioxide and water.
The brown solid dissolves to form a blue solution with effervescence of brown fumes.

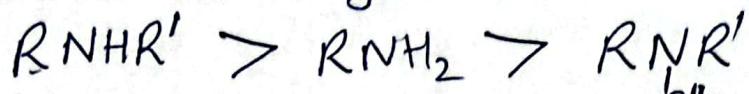


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Qn 8

(a) Basic strength is in the order;



The basic strength of amines in water depends on the availability of lone pair of electrons on the nitrogen atom, and the ease of solvation of the protonated amine. The alkyl groups attached to the nitrogen atom in primary and secondary amines have a positive inductive effect increasing the electron density on the nitrogen atom and making lone pairs readily available to react with protons from water. Secondary amines have more alkyl groups hence a greater positive inductive effect than primary amines.

Tertiary amines have three methyl groups which sterically hinder the approach of a proton towards the nitrogen atom hence the weakest bases.

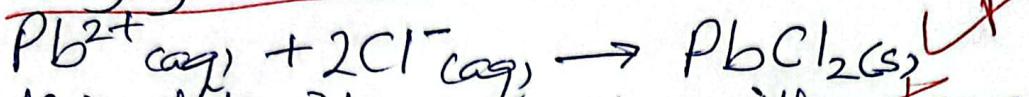
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(b) Decomposition temperature increases from benzylum carbonate to barium carbonate because cationic radius increases from benzylum ion to barium ion, decreasing the charge density and polarising power of the carbonate ion. This makes the ionic character of the carbonates increasingly stronger thus the oppositely charged ions becoming increasingly strongly held.

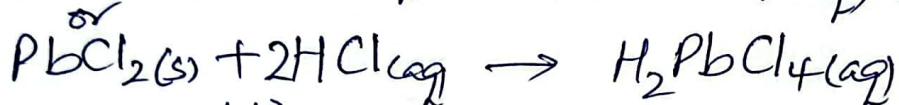
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(2)

(d) Chloride ions react with lead(II) ions to form lead(II) chloride which is sparingly soluble in water. Accept insoluble.

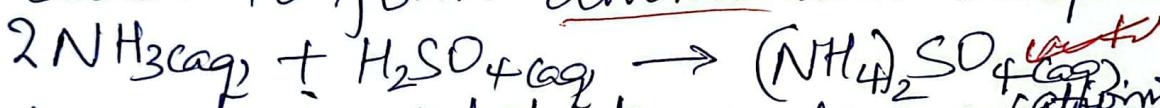


Lead(II) chloride reacts with excess concentrated hydrochloric acid to form a complex tetrachloroplumbate(II) ion, which is soluble.

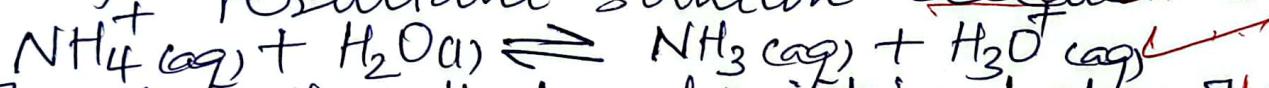


(4)

(d) Ammonia solution reacts with dilute sulphuric acid to form ammonium sulphate.



Ammonium sulphate undergoes hydrolysis to form hydroxonium/hydrogen ions, making resultant solution acidic.



Therefore, the pH at end point is below 7 and within the working range of methyl orange indicator.

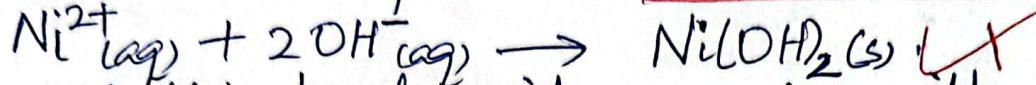
(4)

(e) The nitrogen atom in amines is less electronegative than the oxygen atom in alcohols. The nitrogen-hydrogen bonds in amines are therefore less polar than the oxygen-hydrogen bonds in alcohols. The hydrogen bonds formed between alcohol molecules are therefore stronger than those formed between amine molecules of the same molecular masses.

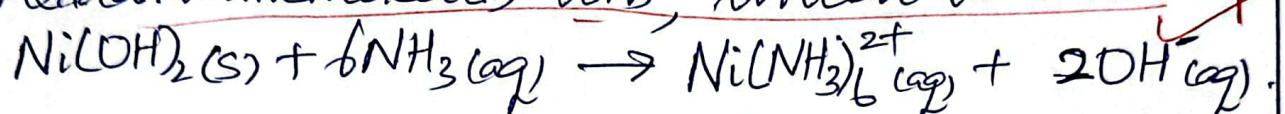
(2)

(23)

(f) Nickel(II) ions react with ammonia solution to form insoluble ~~Nickel(II) hydroxide~~



Nickel(II) hydroxide reacts with excess ammonia to form a complex hexaamminenickel(II) ions, which is soluble.



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END

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