UACE chemistry 2023

PAPER 1

DURATION: 2 HOUR 45 MINUTES

Instructions

- This paper consists of two sections A and B
- Section A is compulsory
- Attempt only six questions in section B
- Answers must be written in the spaces provided only.

Where necessary use the following:

Molar gas constant, R	= $8.31JK^{-1}mol^{-1}$
Molar volume of a gas at stp.	= 22.4litres
Standard temperature	= 273K
Standard pressure	= $10125Nm^{-2}$

For Examiner's Use Only																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

SECTION A

Answer all questions in this section

1. (a) Kinetic data for decomposition of nitrogen (V) oxide is shown in the table 1below

$[N_2O_5]$ ($moldm^{-3}$)	Initial Rate ($mol\ dm^{-3}s^{-1}$)
0.0016	0.12
0.0024	0.18
0.0032	x

Calculate;

(i) Order of the reaction (1 ½ marks)
(ii) Rate constant for the reaction(1 ½ marks)
(iii) Value of x (01marka)

(b) Name two methods used to determine orders of reaction

2. (a) Write an equation to show how soapless detergent can be prepared from alkylbenzene. (02marks)
(b) State
(i) **one** advantage of soapless detergent over soapy detergent. (01mark)
(ii) One disadvantage of soapless detergent over soapy detergent. (01mark)

3. (a) A compound Q consists of 94.11% Sulphur, the rest hydrogen. Calculate the empirical formula of Q (02marks)
(b) When 0.15 g of Q was vaporized at 293K, the vapour produced occupied106cm3 at 101325Nm-2. Determine the molecular formula of Q. (02marks)
(c) Write an equation for the reaction of Q with acidified potassium dichromate (VI) solution

4. (a) The atomic number of cobalt is 27
(i) Write the electron configuration of cobalt (01marl)
(ii) State how cobalt is able to form ions with oxidation states of +2 and +3 (02marks)

(b) When concentrated ammonia solution was added to cobalt (II) chloride solution, a blue precipitate was formed which dissolved giving a red brown solution. Write equation(s) for the reaction(s) that took place (03marks)

5. State what would be observed and write equation(s) for the reaction(s) that would take place when the following pairs of substances are mixed

(a) $CH_3C(CH_3)=CH_2$ and bromine in tetrachloromethane

Observation (01 mark)

Equation (01mark)

(b) $CH_3\overset{\overset{O}{||}}{C}CH_3$ and sodium hydroxide in iodine solution

Observation (½ mark)

Equation (01mark)

(c) $CH_3CH(OH)CH_3$ and acidified potassium dichromate (VI)
Observation (01 mark)
Equation (01mark)

6. (a) Define the term standard enthalpy of formation (01mark)
(b) The bond energies of some bonds are shown in table 2
Table 2

Bond	Bond enthalpy (kJmol-1)
C – H	+413
C – C	+347
C = C	+612

Calculate the enthalpy of formation of but-1-ene. (03marks)
(Standard enthalpies of atomization of carbon and hydrogen are 717 and 218kJmol^{-1} respectively)

7. The boiling points of some chlorides of period 3 elements of the periodic table are shown in table 3
Table 3

Formula of chlorides	NaCl	$MgCl_2$	Al_2Cl_6	$SiCl_4$
Boiling points (^{0}C)	1465	1418	423	57

(a) State the trend in the boing points of chlorides (01mark)
(b) Explain your answer in (a) (05marks)

8. Write equation(s) to show how methylethanoate can be synthesized starting from ethene. (05marks)

9. (a) State **Kohlrauschs law.** (01mark)
(b) The molar conductivity at infinite dilution for some electrolytes at 10C are shown below
$BaCl_2$ $\Lambda_\infty = 240.6\Omega^{-1}cm^2mol^{-1}$
NH_4Cl $\Lambda_\infty = 129.6\Omega^{-1}cm^2mol^{-1}$
$Ba(OH)_2$ $\Lambda_\infty = 457.6\Omega^{-1}cm^2mol^{-1}$
Determine the molar conductivity of NH4OH at 18^{0}C (03marks)
(c) State one application of conductivity measurements (01 mark)

SECTION B (54 MARKS)

Answer any **six** questions from this section

Any additional question(s) answered will **not** be marked

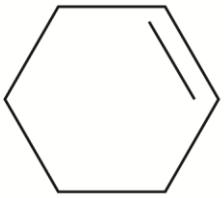
10. Complete each of the following questions and in each case outline a mechanism for the reaction

(a) $(CH_3CH_2)_3C—Br \xrightarrow{CH_3CH_2O\text{-}Na^+/CH_3CH_2OH}$ (01mark)

Mechanism (02mark)

(b) $CH_3CH_2OH \xrightarrow[140^oC]{Conc.\ H_2SO_4}$ (01mark)

Mechanism (02mark)

(c)  $\xrightarrow{HBr}$ (01mark)

Mechanism (02mark)

11. Beryllium and magnesium are elements in group (II) of the Periodic Table
    (a) Explain the following
        (i) The first ionization energy of beryllium is higher than that of magnesium (02marks)
        (ii) The polarizing power of magnesium ions is lower than that of beryllium ions(01mark)
    (b) Beryllium reacts with aqueous sodium hydroxide solution. Write an equation for the reaction (1 ½ marks)
    (c) State the conditions under which beryllium and magnesium oxides react with the following substances and where applicable, write equation(s) for the reaction(s):
        (i) Water (02marks)
        (ii) Sodium hydroxide (2 ½ marks)

12. (a) Calcium phosphate (V), $Ca_3(PO_4)_2$, is sparingly soluble in water.
    Write the;
    (i) Equation for the solubility of calcium phosphate (V) in water (01marks)
    (ii) Expression for the solubility product, **Ksp**, of calcium phosphate (V) (01mark)

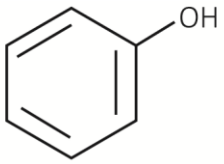
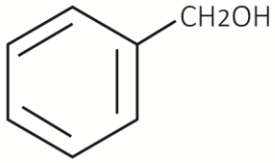
    (b) The solubility product of calcium phosphate (V) is $2.0 \times 10^{-29} mol5dm^{-15}$ at 25^0C. Calculate the solubility of calcium phosphate (V) in gdm-3 at 25^0C (03marks)

(c) Explain how the solubility of calcium phosphate (V), would be affected if to its solution a few drops of;

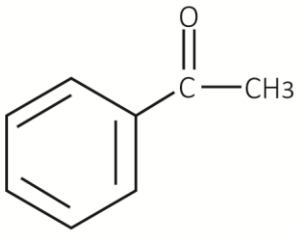
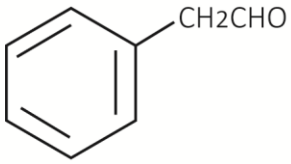
(i) aqueous sodium phosphate (V) were added (02marks)

(ii) dilute nitric acid were added (02marks)

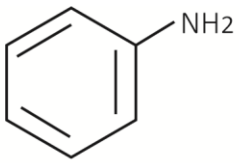
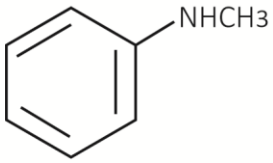
13. Name one reagent which can be used to distinguish between the following pairs of compounds and in each case state what would be observed if each member is separately treated with the reagent

(a)  and  (03mark)

Reagent
Observation

(b)  and  (03mark)

Reagent
Observation

(c)  and  (03mark)

Reagent:
Observation

14. (a) Some elements in group (IV) of the Periodic Table are given in table 4
Complete the table by;
(i) Writing the formula of the oxide in which each element is in the +4 oxidation state (1½ marks)
(ii) Stating the class of each oxide (1½ marks)

Table 4

Element	Formula of oxide	Class of oxide
Tin	SnO_2	amphoteric
Silicon	SiO_2	acidic
Lead	PbO_2	amphoteric

(b) Write an equation for the reaction between;

(i) tin (IV) oxide and concentrated sodium hydroxide (1 ½ marks)

(ii) Lead (IV) oxide and cold concentrated hydrochloric acid. (1 ½ marks)

(c) State the conditions and write an equation for the reaction between concentrated nitric acid and;

(i) tin

Condition (½ marks)

Equation (01mark)

(ii) lead

Condition (½ marks)

Equation (01mark)

15. (a) Write an equation for ionization of benzoic acid in water. (01marks)
(b) Calculate the pH of a solution containing 2.06g of benzoic acid per dm^3. (04marks)
(the acid dissociation constant, Ka, for benzoic acid = $6.3 \times 10^{-5} moldm^{-3}$)
(c) 4.32g of sodium benzoate was dissolved in one dm3 of benzoic acid in (b). Calculate the pH of the resultant solution. (04 marks)

16. (a) During the extraction of aluminium from Bauxite, $Al_2O_3.2H_2O$, the ore is purified
(i) Name two major impurities in the ore. (01marks)
(ii) Write equations to show how the ore is purified. (06marks)

(b) Describe how aluminium is obtained from the pure ore (02marks)

(Equations are **not** required)

17. (a) State what is meant by the term partition coefficient. (01mark)
(b) 4.5g of an impure sample of zinc sulphide was dissolved in excess concentrated solution of ammonia and the solution of ammonia and the solution diluted to $500cm^3$. The resultant solution was shaken with 25 cm^3 of carbon tetrachloride and allowed to settle.

12.5cm^3 of aqueous layer required 20cm^3 of 0.25M hydrochloric acid for complete reaction, while 25cm^3 of carbon tetrachloride layer required 12.5cm^3 of a 0.025M hydrochloric acid for complete reaction.

Calculate

(i) free ammonia in aqueous layer.
(The partition coefficient, $\mathbf{K_D}$, for ammonia between carbon tetrachloride and water is 0.04) (2 ½ marks)

(ii) Complexed ammonia (2 ½ marks)

(c) Determine the percentage by mass of zinc in the impure sulphide. (03mark)

Suggested solution

1. (a) Kinetic data for decomposition of nitrogen (V) oxide is shown in the table 1below

$[N_2O_5]$ ($moldm^{-3}$)	Initial Rate (mol d $m^{-3}s^{-1}$)
0.0016	0.12
0.0024	0.18
0.0032	x

Calculate;

(i) Order of the reaction (1 ½ marks)

Let the order be x

$$xlog\left(\frac{0.0024}{0.0016}\right) = log\left(\frac{0.18}{0.12}\right)$$

$$x = 1$$

Therefore the order of reaction = 1

(ii) Rate constant for the reaction(1 ½ marks)

k(0.0016) = 0.12

rate constant k = 75

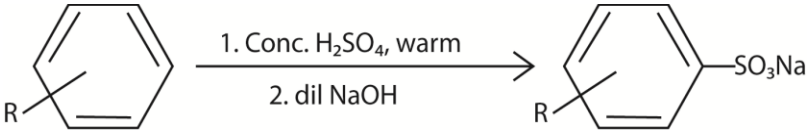
(iii) Value of x (01marka)

x = 75 (0.0032) = 0.24

(b) Name two methods used to determine orders of reaction

- Titration
- Measuring the rate formation of turbidity/cloudiness
- Measuring rate of change color intensity
- Measuring rate of change of volume.

2. (a) Write an equation to show how soapless detergent can be prepared from alkylbenzene. (02marks)



(b) State

(i) **one** advantage of soapless detergent over soapy detergent. (01mark)

Foams in hard water

(ii) One disadvantage of soapless detergent over soapy detergent. (01mark)

Non-biodegradable

3. (a) A compound Q consists of 94.11% Sulphur, the rest hydrogen. Calculate the empirical formula of Q (02marks)

Elements	S	H

Percentage	94.11	5.89
Atomic mass	32	1
Number of moles	2.94	5.89
Mole ratio	1	2

Empirical formula H_2S

(b) When 0.15 g of Q was vaporized at 293K, the vapour produced occupied106cm^3 at 101325Nm^{-2}.

Determine the molecular formula of Q. (02marks)

Number of moles of the gas n = $\frac{PV}{RT} = \frac{101325\ x\ 106\ x\ 10^{-6}}{8.31\ x\ 293}$ = 0.00441

Molecular mass = $\frac{mass}{moles} = \frac{0.15}{0.00441}$ = 34

=> $(H_2S)n$ = 34

34n = 34; n = 1

Therefore molecular formula = H_2S

(c) Write an equation for the reaction of Q with acidified potassium dichromate (VI) solution

It reacts in presence of sulphuric acid as follows

$Cr_2O_7^{2-}$ (aq) + $8H^+$ (aq) + $3H_2S$ (g) $\longrightarrow$ $2Cr^{3+}$ (aq) + $7H_2O$ (l) + 3S (s)

4. (a) The atomic number of cobalt is 27

(i) Write the electron configuration of cobalt (01marl)

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 d^7$

(ii) State how cobalt is able to form ions with oxidation states of +2 and +3 (02marks)

It form oxidation state +2 after losing two electrons to form a stable half-full d-orbital i.e. $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 d^5$

It form oxidation state +3 after losing 3 electrons $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 d^4$

(b) When concentrated ammonia solution was added to cobalt (II) chloride solution, a blue precipitate was formed which dissolved giving a red brown solution. Write equation(s) for the reaction(s) that took place (03marks)

It forms a blue ppt. of cobalt hydroxide that dissolves in excess to form a red brown-complex

$[Co(H_2O)_6]^{2+}$ (aq) + $2OH^-$ (aq) $\rightarrow$ $Co(OH)_2$ (s) + $6NH_3$ (aq) s $\rightarrow$ $[Co(NH_3)_6]^{2+}$(aq)

pink blue ppt red-brown

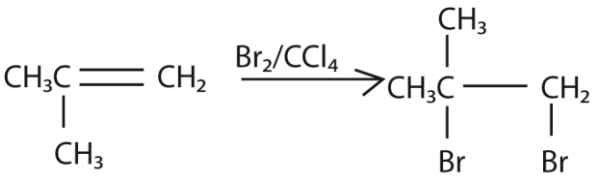
5. State what would be observed and write equation(s) for the reaction(s) that would take place when the following pairs of substances are mixed

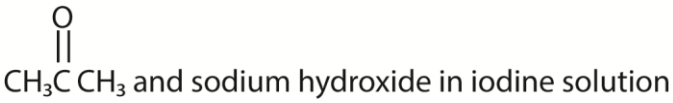
(a) $CH_3C(CH_3)=CH_2$ and bromine in tetrachloromethane

Observation (01 mark)

Tetrachloromethane decolorized

Equation (01mark)

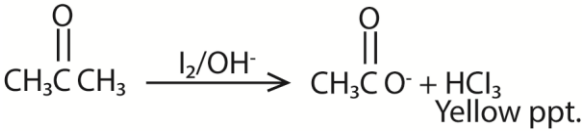


(b) 

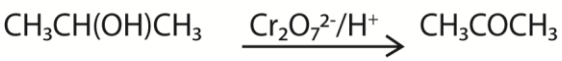
Observation (½ mark)

A yellow ppt. formed

Equation (01mark)



(c) $CH_3CH(OH)CH_3$ and acidified potassium dichromate (VI)
Observation (01 mark)
The solution turns from orange to green
Equation (01mark)

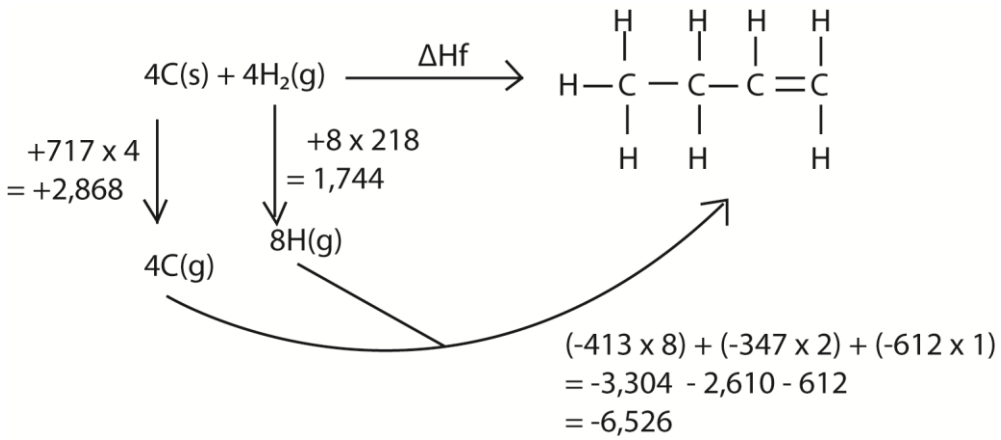


6. (a) Define the term standard enthalpy of formation (01mark)

(b) The bond energies of some bonds are shown in table 2
Table 2

Bond	Bond enthalpy (kJmol-1)
C – H	+413
C – C	+347
C = C	+612

Calculate the enthalpy of formation of but-1-ene. (03marks)
(Standard enthalpies of atomization of carbon and hydrogen are 717 and 218kJmol^{-1} respectively)
Note: enthalpy for bond breakage is positive while that for bond formation is negative



$\Delta Hf = 2,868 + 1744 – 6526 = -1,914\ kJmol^{-1}$

Therefore the enthalpy of formation of but-1-ene = $-1,914\ kJmol^{-1}$.

7. The boiling points of some chlorides of period 3 elements of the periodic table are shown in table 3

Table 3

Formula of chlorides	NaCl	$MgCl_2$	Al_2Cl_6	$SiCl_4$
Boiling points (^0C)	1465	1418	423	57

(a) State the trend in the boing points of chlorides (01mark)

There is slight decrease in the boiling points from NaCl to $MgCl_2$ and a steep decrease of boiling points from $MgCl_2$ to $SiCl_4$.

(b) Explain your answer in (a) (05marks)

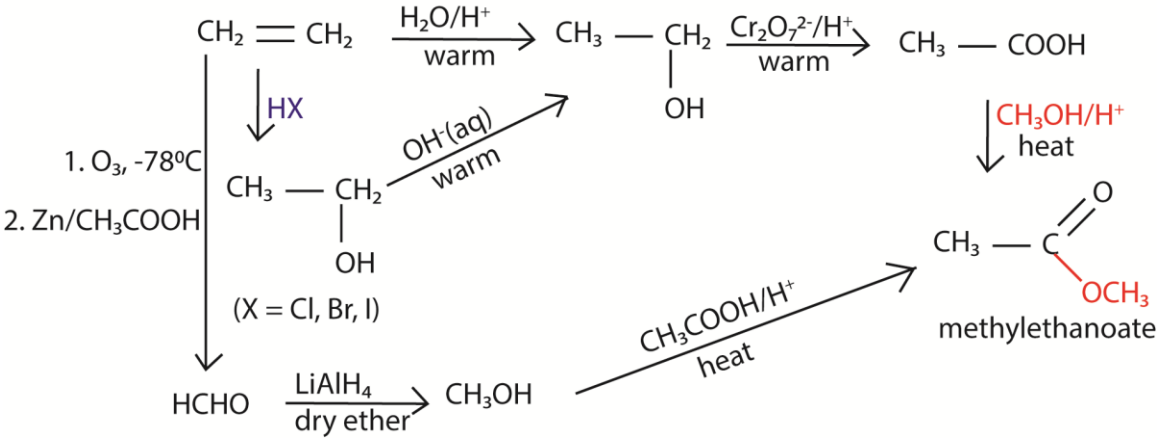
NaCl and $MgCl_2$ have high boiling points due to the strength of the ionic bonding.

The boiling point of NaCl is higher than that Mg_2Cl_2 because NaCl has strong ionic forces than Magnesium chloride since Na is more electropositive than Mg.

$AlCl_3$ has a fairly high boiling point because in the solid state, it consists of Al_2Cl_6 molecules and not simple $AlCl_3$ and it is partially ionic.

$SiCl_4$ has very boiling point because it exist as simple $SiCl_4$ molecules held by weak van der Waals forces

8. Write equation(s) to show how methylethanoate can be synthesized starting from ethene. (05marks)



9. (a) State **Kohlrauschs law.** (01mark)

The molar conductivity of a electrolyte at infinite dilution is the sum of molar conductivity of the constituent ions at infinite dilution.

(b) The molar conductivity at infinite dilution for some electrolytes at 10C are shown below

$BaCl_2$ $\Lambda_\infty = 240.6\Omega^{-1}cm^2mol^{-1}$

NH_4Cl $\Lambda_\infty = 129.6\Omega^{-1}cm^2mol^{-1}$

$Ba(OH)_2$ $\Lambda_\infty = 457.6\Omega^{-1}cm^2mol^{-1}$

Determine the molar conductivity of NH_4OH at 18^0C (03marks)

$\Lambda[NH_4OH] = ½ \{ \Lambda[Ba(OH)_2] + 2 \Lambda[NH_4Cl] - \Lambda[BaCl_2]\}$

$= ½ \{457.6 + 2 \times 129.6 - 240.6\}$

$= 238.1\Omega^{-1}cm^2mol^{-1}$

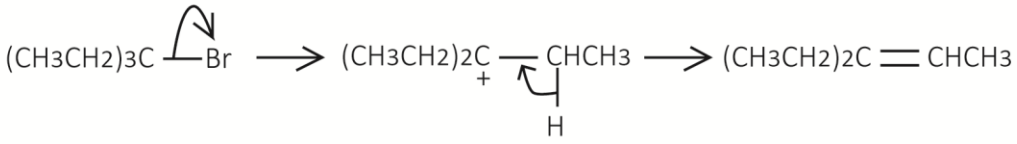
(c) State one application of conductivity measurements (01 mark)

- Determine end points in conductometric titration
- To find concentration of solutions
- Determine salinity of water

10. (a) $(CH_3CH_2)_3C—Br \xrightarrow{CH_3CH_2O\text{-}Na^+/CH_3CH_2OH} (CH_3CH_2)_2C = CHCH_3$ (01mark)

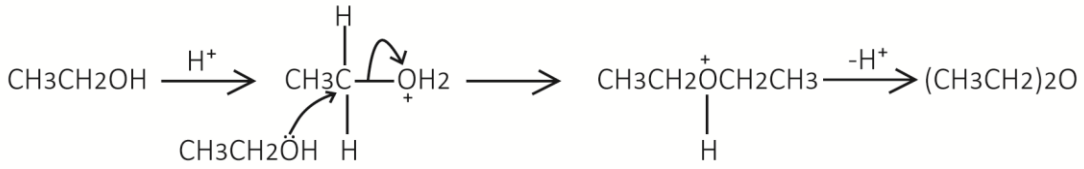
(02mark)

Mechanism



(b) $CH_3CH_2OH \xrightarrow[140^oC]{\text{Conc. } H_2SO_4} CH_3CH_2OCH_2CH_3$ (01mark)

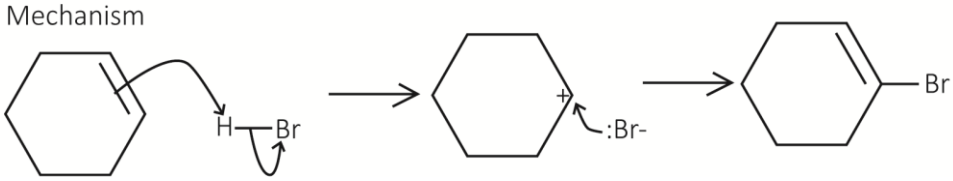
Mechanism (02mark)



(c)

(01mark)

Mechanism (02mark)



11. Beryllium and magnesium are elements in group (II) of the Periodic Table

(a) Explain the following

(i) The first ionization energy of beryllium is higher than that of magnesium (02marks)
Because beryllium is more electronegative than magnesium thus, their electrons are more strongly attracted to the nucleus.

(ii) The polarizing power of magnesium ions is lower than that of beryllium ions(01mark)
Magnesium ions have a lower charge density since magnesium ions are larger than those of beryllium ion yet both ions possess the same charge

(b) Beryllium reacts with aqueous sodium hydroxide solution. Write an equation for the reaction (1 ½ marks)

$Be(s) + 2OH^-(aq) \rightarrow BeO^{2-}(aq) + H_2(g)$

Or

$Be(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow [Be(OH)_4]^{2-}(aq) + H_2(g)$

(c) State the conditions under which beryllium and magnesium oxides react with the following substances and where applicable, write equation(s) for the reaction(s):

(i) Water (02marks)

BeO does not react with water

$MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$

(ii) Sodium hydroxide (2 ½ marks)

MgO does not react with sodium hydroxide

$BeO(s) + 2NaOH(aq) \rightarrow Na_2BeO_2(aq) + H_2O(l)$

12. (a) Calcium phosphate (V), $Ca_3(PO_4)_2$, is sparingly soluble in water.
Write the;

(i) Equation for the solubility of calcium phosphate (V) in water (01marks)
$Ca_3(PO_4)_2(s) \rightarrow 3Ca^{2+}(aq) + 2PO_4^{3-}(aq)$

(ii) Expression for the solubility product, **Ksp**, of calcium phosphate (V) (01mark)
$Ksp = [Ca^{2+}]^3[PO_4^{3-}]^2$ mol^5dm^{-15}

(b) The solubility product of calcium phosphate (V) is $2.0 \times 10^{-29} mol^5dm^{-15}$ at 25^0C. Calculate the solubility of calcium phosphate (V) in gdm^{-3} at 25^0C (03marks)

Let the solubility of $Ca_3(PO_4)_2$ be $xmoldm^{-3}$

⇨ $Ca_3(PO_4)_2(s) \rightarrow 3Ca^{2+}(aq) + 2PO_4^{3-}(aq)$
x 3x 2x
$Ksp = [3x]^3[2x]^2 = 2.0 \times 10^{-29}$
$108x^5 = 2.0 \times 10^{-29}$
$x = 7.1371 \times 10^{-7} moldm^{-3}$

Formula mass of $Ca_3(PO_4)_2 = 40.1 \times 3 + 2(31 + 16 \times 4) = 310.3$

Concentration in $gdm^{-3} = 7.1371 \times 10^{-7} \times 310.3 = 2.2146 \times 10^{-4} gdm^{-3}$

(c) Explain how the solubility of calcium phosphate (V), would be affected if to its solution a few drops of;

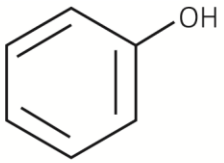
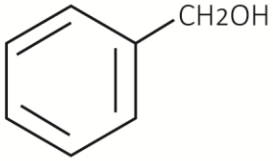
(i) aqueous sodium phosphate (V) were added (02marks)

Solubility decreases due to common ion effect, i.e. release of phosphate ions from sodium phosphate (V) suppresses ionization of calcium phosphate (V)

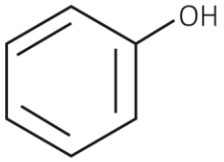
(ii) dilute nitric acid were added (02marks)

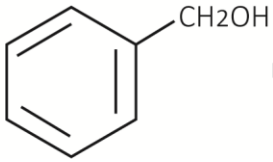
Solubility increase due to formation of soluble calcium nitrate and phosphoric acid

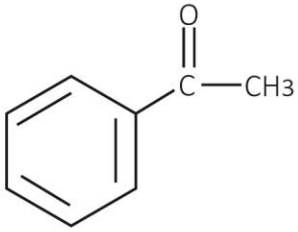
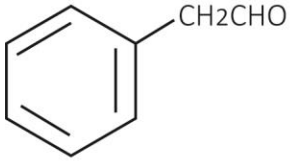
13. Name one reagent which can be used to distinguish between the following pairs of compounds and in each case state what would be observed if each member is separately treated with the reagent

(a)  and  (03mark)

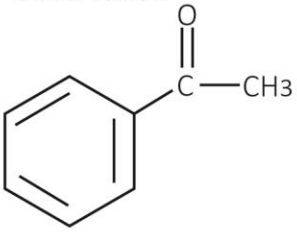
Reagent: neutral iron (III) chloride
Observation

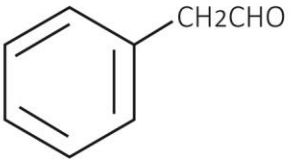
 purple solution formed

 no observable change

(b)  and  (03mark)

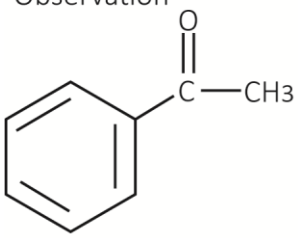
Reagent: Ammoniacal silver nitrate
Observation

 no observable change

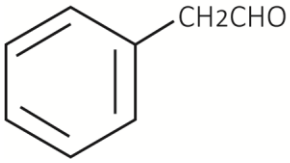
 black ppt./silver mirror

Or

Reagent: Fehlings solution
Observation



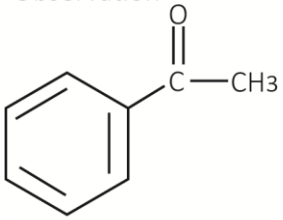
no observable change



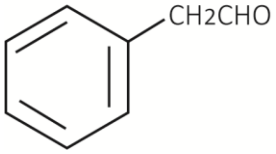
red ppt.

Or

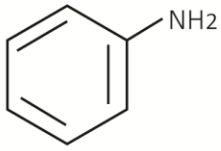
Reagent: I2/NaOH
Observation

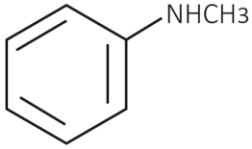


yellow ppt



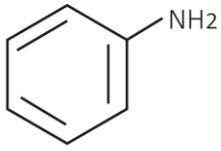
no observable change

(c) 

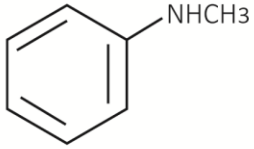
and 

(03mark)

Reagent: NaNO2/HCl <5°C
Observation



no observable change



yellow oily solution

14. (a) Some elements in group (IV) of the Periodic Table are given in table 4
Complete the table by;
(iii) Writing the formula of the oxide in which each element is in the +4 oxidation state (1½ marks)
(iv) Stating the class of each oxide (1½ marks)

Table 4

Element	Formula of oxide	Class of oxide
Tin	SnO_2	amphoteric
Silicon	SiO_2	acidic
Lead	PbO_2	amphoteric

(b) Write an equation for the reaction between;

(i) tin (IV) oxide and concentrated sodium hydroxide (1 ½ marks)

SnO_2 (s) + 2^-OH (aq) + $2H_2O$ (l) $\rightarrow$ $[Sn(OH)_6]^{2-}$ (aq)

(ii) Lead (IV) oxide and cold concentrated hydrochloric acid. (1 ½ marks)

PbO_2 (s) + 4HCl (aq) $\rightarrow$ $PbCl_4$(aq) + $2H_2O$(l)

(c) State the conditions and write an equation for the reaction between concentrated nitric acid and;

(i) tin

Condition (½ marks)

heat

Equation (01mark)

Sn(s) + $4HNO_3$ (aq) $\rightarrow$ SnO_2 (s)+ $4NO_2$(g) + $2H_2O$(l)

(ii) lead

Condition (½ marks)

heat

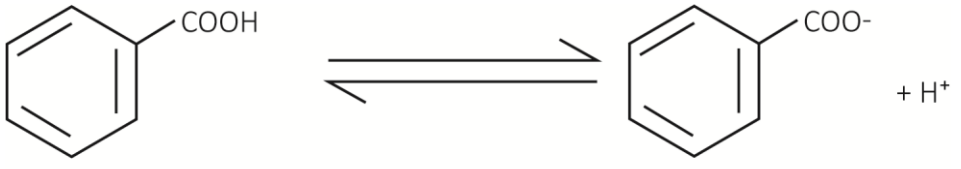
Equation (01mark)

Pb(s) +$4HNO_3$ (aq) (Conc.) $\rightarrow$ $Pb(NO_3)_2$ (aq) +$2NO_2$(g) +$2H_2O$(l)

Or

Sn(s) + $4HNO_3$ (conc.) $\rightarrow$ H_2SnO_3(aq) +$4NO_2$(g) + H_2O(l)

15. (a) Write an equation for ionization of benzoic acid in water. (01marks)



Or

$C_6H_5COOH(aq) \rightleftharpoons C_6H_5COO^-(aq) + H^+(aq)$

(b) Calculate the pH of a solution containing 2.06g of benzoic acid per dm^3. (04marks)
(the acid dissociation constant, Ka, for benzoic acid = $6.3 \times 10^{-5} moldm^{-3}$)

Formula mass C_6H_5COOH= 12 x 6 + 1 x 5 + 12 + 16 x 2 + 1 = 122

Molarity of the solution = $\frac{2.06}{122}$ = $0.0169 moldm^{-3}$.

Let the concentration of H^+ in solution be x

Then $\frac{x^2}{0.0169} = 6.3\ x\ 10^{-5}$

[H=] = $\sqrt[2]{(0.0169\ x\ 6.3\ x\ 10^{-5})} = 0.001$

pH = -log(0.001) = 3

(c) 4.32g of sodium benzoate was dissolved in one dm^3 of benzoic acid in (b). Calculate the pH of the resultant solution. (04 marks)

Formula mass of C_6H_5COONa = 144

Molarity of the solution = $\frac{4.32}{144}$ = $0.03 moldm^3$.

[H+] = Ka$\frac{[C_6H_5COOH]}{[C_6H_5COO^-]}$= $6.3 \times 10^{-5}\left(\frac{0.0169}{0.03}\right) = 3.549 \times 10^{-5} moldm\text{-}3$

pH = -log(3.549×10^{-5}) = 4.4

16. (a) During the extraction of aluminium from Bauxite, $Al_2O_3.2H_2O$, the ore is purified

(i) Name two major impurities in the ore. (01marks)

silica (SiO_2)and iron (III) oxide (Fe_2O_3)

(ii) Write equations to show how the ore is purified. (06marks)

Equations for reaction of impure ore with sodium hydroxide to eliminate isoluble iron (III) oxide

$Al_2O_3(s) + 2NaOH(aq) + 7H_2O(l) \rightarrow 2Na[Al(OH)_4(H_2O)_2](aq)$

$SiO_2(s) + 2NaOH(aq) \rightarrow Na_2SiO_3(aq) + H_2O(l)$

Precipitation of pure Al(OH)2 to eliminate silca. A little aluminium hydroxide is added to the filtrate after dilution with water (hydrolysis) to cause precipitation (seeding).

$NaAlO_2(aq) + 2H_2O(l) \rightarrow NaOH(aq) + Al(OH)_3(s)$

Decomposition of $Al(OH)_3$ to form pure Al_2O_3 on heating

$2Al(OH)_3\ (s) \rightarrow Al_2O_3\ (s) + 3H_2O\ (g)$

(b) Describe how aluminium is obtained from the pure ore (02marks)

(Equations are **not** required)

Cryolite, Na_3AlF_6, is mixed with the oxide to lower the melting point to about 900^0C and to improve conduction of the molten oxide. The molten oxide is electrolyzed between carbon electrodes. Aluminium is liberated at the cathode.

17. (a) State what is meant by the term partition coefficient. (01mark)

A partition coefficient is the ratio of the concentration of a solute between two immiscible solvents at equilibrium

(b) 4.5g of an impure sample of zinc sulphide was dissolved in excess concentrated solution of ammonia and the solution diluted to $500cm^3$. The resultant solution was shaken with 25 cm^3 of carbon tetrachloride and allowed to settle.
$12.5cm^3$ of aqueous layer required $20cm^3$ of 0.25M hydrochloric acid for complete reaction, while $25cm^3$ of carbon tetrachloride layer required $12.5cm^3$ of a 0.025M hydrochloric acid for complete reaction.
Calculate

(i) free ammonia in aqueous layer.

(The partition coefficient, $\mathbf{K_D}$, for ammonia between carbon tetrachloride and water is 0.04) (2 ½ marks)

Moles of HCl that reacted = moles of free ammonia in $25cm^3$ of CCl_4

$$= \frac{12.5\ x\ 0.025}{1000}$$

$= 3.125 \times 10^{-4}$ moles

From KD = $\frac{(free\ NH_3 in\ CCl_4]}{(free\ NH_3 in H_2O]}$

Moles of free ammonia in $500cm^3$ of aqueous layer = $\frac{3.125\ x\ 10^{-4}}{0.04}$

$= 7.8125 \times 10^{-3}$ moles

(ii) Complexed ammonia (2 ½ marks)

Moles of ammonia in $12.5cm^3$ of aqueous layer = $\frac{20\ x\ 0.25}{1000}$

Mole of ammonia in 500cm3 of aqueous layer = $\frac{20\ x\ 0.25}{1000} x \frac{500}{12.5}$ = 0.2moles

Moles of complexed ammonia = 0.2 – 0.0078125 = 0.1922 moles

(c) Determine the percentage by mass of zinc in the impure sulphide. (03mark)

Moles of Zn2+ = $\frac{0.1922}{4}$ = 0.048moles

Mass of pure zinc = 0.048 x 65.7 = 3.1536g

Percentage of Zn = $\frac{3.1536}{4.5} x 100\%$ = 70.08%

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