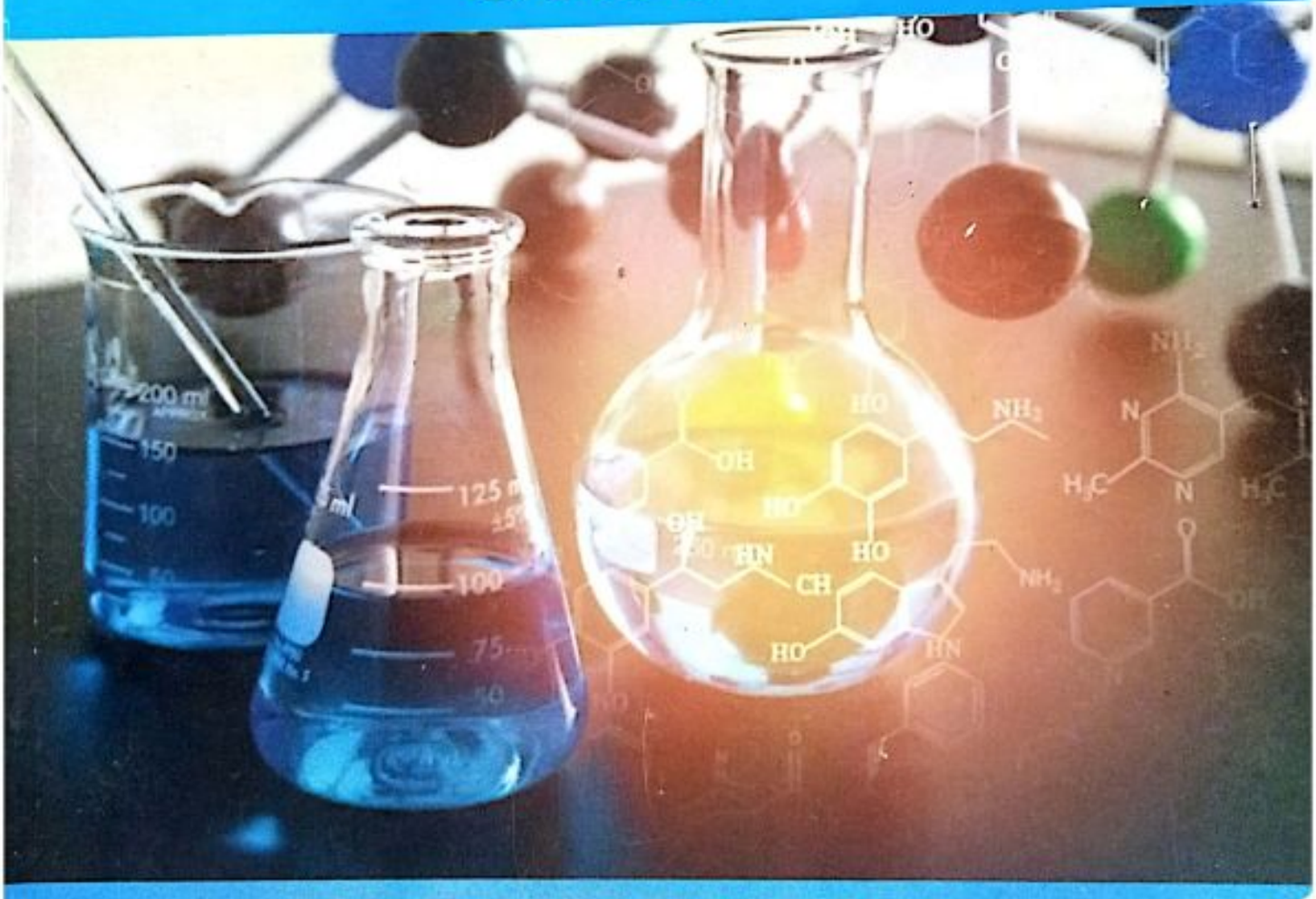
ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

DIAMOND KEY

CHEMISTRY 6031



GCE ADVANCED LEVEL

Volume 1

November 2018 - November 2019 Examinations

TABLE OF CONTENTS

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

CHEMISTRY 6031/1

PAPER 1 Multiple Choice

NOVEMBER 2018 SESSION 1 hour

Additional materials:
- Data booklet
- Multiple Choice answer sheet
- Soft clean eraser
- Soft pencil (type B or HB is recommended)
- Electronic calculator and/or Mathematical tables

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.
Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has already been done for you.

There are **forty** questions in this paper. Answer **all** questions. For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate answer sheet.

Read very carefully the instructions on the answer sheet.

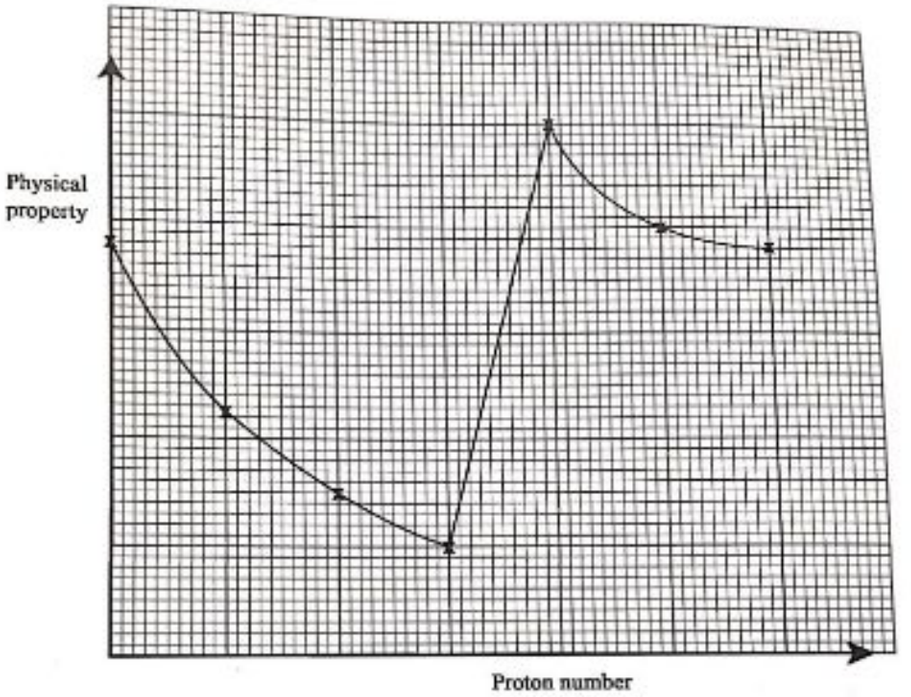
INFORMATION FOR CANDIDATES

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any rough working should be done in this booklet.

Section A

1 The graph shows how a physical property of the elements Na to Cl varies with proton number.



Which property is shown?

A electronegativity
B first ionisation energy
C ionic radius
D melting point

2 Which property increases on descending Group (IV) of the Periodic Table?

A covalent character of the chlorides
B acidity of the oxides
C melting point of the elements
D stability of the oxidation state (II)

3 Which bond is least polar?

A H – F
B Br – F
C Cl – F
D F – F

4 An electrical cell constructed for the reaction,

$$Cu^{2+}_{(aq)} + M_{(s)} \rightarrow Cu_{(s)} + M^{2+}_{(aq)},$$

has an E^{θ}_{cell} value of 0.750 V.

What is the standard reduction potential for $M^{2+}_{(aq)}$?

A −1.090 v
B +0.410 v
C −0.410 v
D +1.090 v

5 Which reaction does **not** involve the non-bonding pair of electrons on the nitrogen atom of ammonia?

A $NH_{3(g)} + CH_3I_{(g)} \rightarrow CH_3NH^+_3I^-_{(s)}$

B $NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(s)}$

C $2NH_{3(l)} + 2Na_{(s)} \rightarrow 2NaNH_{2(s)} + H_{2(g)}$

D $2NH_{3(aq)} + Ag^+_{(aq)} \rightarrow [Ag(NH_3)_2]^+_{(aq)}$

6 Which substance can be used to separate Ca^{2+} ions from Cu^{2+} ions in an aqueous solution of $Cu(NO_3)_2$ and $Ca(NO_3)_2$?

A HCl
B H_2SO_4
C H_2S
D NaOH

7 The equation shows the reaction that takes place when a matchstick head burns.

$$P_4S_3 + 5KClO_3 + \tfrac{1}{2}O_2 \rightarrow 5KCl + 3SO_2 + 2P_2O_5$$

Which statement is true about the reaction?

A It is a disproportionation reaction.
B It is a reduction reaction only.
C It is an oxidation reaction only.
D It is a redox reaction.

8 Lead (IV) oxide reacts with concentrated hydrochloric acid as shown.

$$PbO_{2(s)} + 4HCl_{(l)} \rightarrow PbCl_{2(s)} + 2H_2O_{(l)} + Cl_{2(g)}$$

What can be deduced from this reaction about PbO_2?

A It is a reducing agent.
B It is an acidic oxide.
C It is an amphoteric oxide.
D It is an oxidising agent.

9 Which source of energy results in the **least** damage to the environment?

A nuclear
B solar
C biogas
D fossil fuel

10 What is the E^{θ}_{cell} for the reaction between Co^{3+} and water under acidic conditions?

A -0.59 V
B $+0.59$ V
C -1.51 V
D $+1.66$ V

11 Discharging raw sewage into water bodies

A pollutes groundwater.
B destroys aquatic plants.
C increases the amount of oxygen.
D increases pH of water.

12 Which statement correctly describes how sulphur dioxide prevents the spoilage of food by microbial activity?

A increases the pH of food
B lowers the pH of food
C produces a chocking pungent smell
D oxidises bacterial cell walls

13 Which hydride readily decomposes when heated with a hot glass rod?

A ammonia
B hydrogen chloride
C hydrogen fluoride
D hydrogen iodide

14 NO_2 is involved in the formation of acid rain by

A oxidising sulphur dioxide to sulphur trioxide.
B reacting with water vapour to form nitric acid.
C changing water molecules into $H^+_{(aq)}$ ions.
D reacting with water vapour and oxygen to form nitric acid.

15 Which atom has 6 unpaired electrons?

A aluminium
B chromium
C cobalt
D scandium

16 Which molecule is planar?

A CCl_4
B C_2Cl_4
C C_3H_6
D C_3H_8

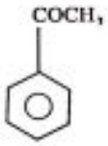
17 Silicon (IV) oxide exists as a

A giant metallic structure.
B giant covalent structure.
C simple ionic structure.
D simple molecular structure.

18 Why is titanium used as an anode in the electrolysis of brine?

A helps to form pure products
B operates as a catalyst
C helps in the transfer of electrons
D resists corrosion by chlorine

19 The structural formulae of the organic compounds, **P** and **Q** are shown.



P

Q

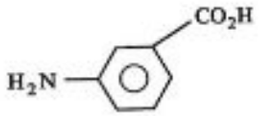
Which reagent can be used to distinguish between the two organic compounds?

A $Br_{2(aq)}$ in the presence of $FeCl_3$
B alkaline I_2
C 2,4 – dinitrophenylhydrazine
D cold alkaline $KMnO_4$

20 Which organic compound reacts with itself to form a condensation polymer?

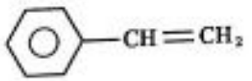
A $HO_2C(CH_2)_4CO_2H$

B

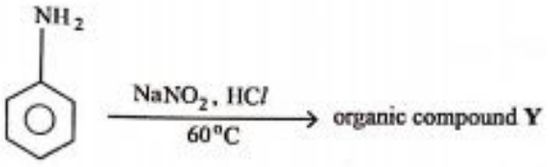


C $H_2N(CH_2)_6NH_2$

D

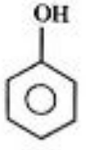


21 Phenylamine can be converted to compound **Y** as shown.

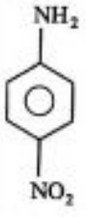


What is the organic product **Y**?

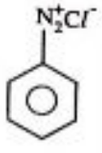
A



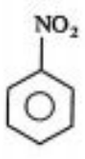
B



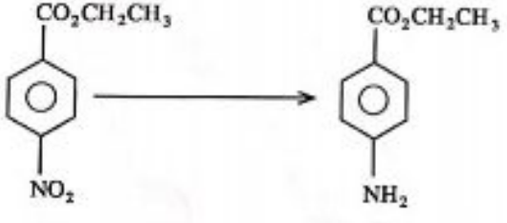
C



D



22 A compound **Z** is obtained from **W** as shown by the reaction.



W **Z**

The reaction is an example of

A a substitution reaction
B an oxidation reaction.
C a hydration reaction.
D a reduction reaction.

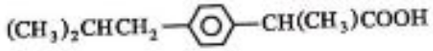
23 Polyvinylchloride (PVC) is removed from any waste that is to be incinerated because it

A does not burn easily.
B can be melted down and re-used.
C produces compounds that destroy the ozone layer.
D causes acid rain.

24 How many chiral centres does the shown molecule have?

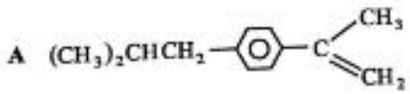
A 0
B 1
C 2
D 3

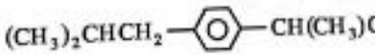
25 The diagram shows the structural formula of Ibuprofen.

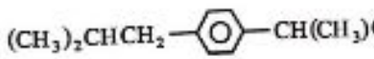


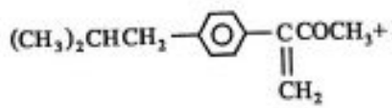
Ibuprofen

Which reaction would lead to its formation?

A  + hot concentrated $KMnO_4$

B  + warm acidified $K_2Cr_2O_{7(aq)}$

C  + warm $H_2SO_{4(aq)}$

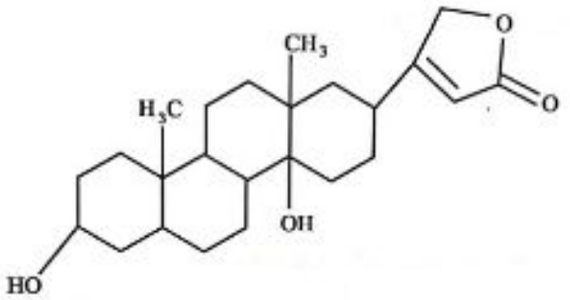
D  + H_2/Pt catalyst

26 An organic compound has the molecular formula $C_4H_8O_2$.

Which pair of functional groups are present in one of the structures of the organic compound?

A aldehyde and alcohol
B alcohol and ester
C aldehyde and ketone
D ketone and ester

27 The diagram shows the structure of digitoxin.



digitoxin

How many functional groups are in digitoxin?

A 5
B 4
C 3
D 2

28 An organic compound, of molecular formula C_6H_6, reacts with chlorine under suitable conditions as shown:

$$C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl$$

Which term correctly describes this type of reaction?

A electrophilic substitution
B free radical substitution
C nucleophilic addition
D nucleophilic substitution

29 Which process is **not** an application of nano materials.

A drug delivery
B bio-remediation
C water treatment
D drug synthesis

30 A solution of 10 g of a carboxylic acid in 100 cm^3 of water was shaken with 100 cm^3 of ethoxyethane. 6.5 g of the acid remained in the aqueous solution at equilibrium.

What is the partition co-efficient?

A 0.54
B 0.65
C 1.86
D 3.00

SECTION B

For each of the questions in this section, one or more of the three numbered statements 1 to 3 may be correct.

Decide whether each of the statements is or is not correct.

The responses A to D should be selected on the basis of

A	B	C	D
1,2 and 3 are correct	*1 and 2 only are correct*	*2 and 3 only are correct*	*1 only is correct*

No other combination of statements is used as a correct response.

31 The equation shows how potassium permanganate reacts with hydrogen peroxide in acidic conditions.

$$2MnO_4^- + 5H_2O_2 + 6H^+ \rightarrow 2Mn^{2+} + 8H_2O + 5O_2$$

Which statement(s) about this reaction is/are correct?

1. Hydrogen peroxide is oxidised to oxygen.
2. Hydrogen ions are oxidised to water.
3. The oxidation number of manganese changes by 6.

32 How are oxides of carbon and nitrogen removed from vehicle exhaust gases in the catalytic converter?

1. Oxides of nitrogen are decomposed to nitrogen gas.
2. Carbon monoxide is converted to carbon dioxide.
3. Carbon monoxide is converted to carbon.

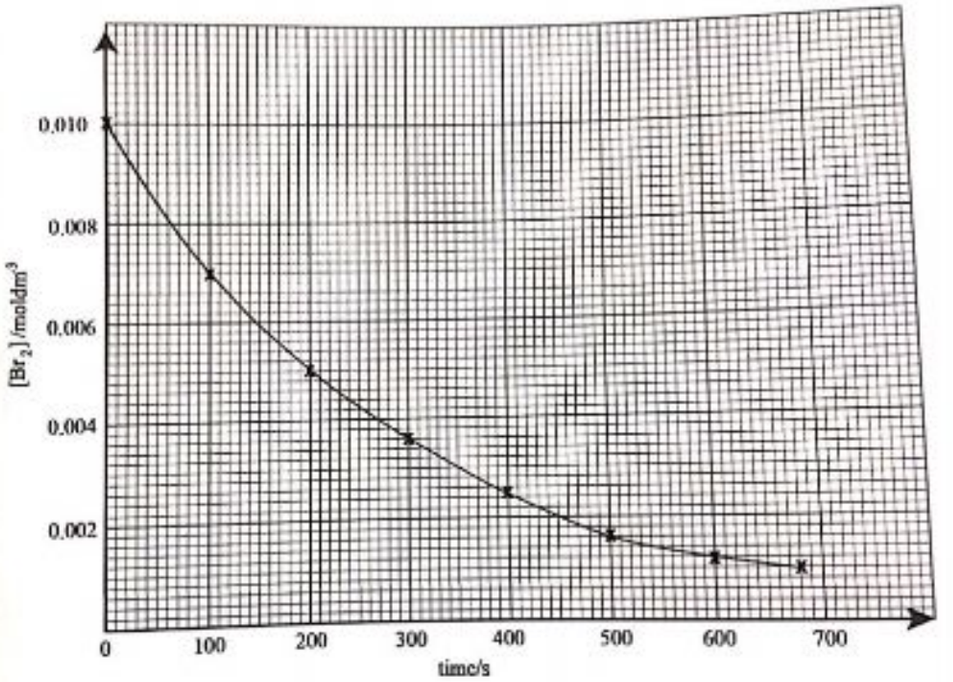
33 Which statement(s) about $GeCl_4$ is/are correct?

1. It is covalently bonded with *Van der Waal* forces between molecules.
2. Its molecule is tetrahedral in shape.
3. It cannot be hydrolysed by water.

34 Bromine reacts with methanoic acid according the equation

$$Br_{2(aq)} + HCO_2H_{(aq)} \rightarrow 2Br^-_{(aq)} + 2H^+_{(aq)} + CO_{2(aq)}$$

The graph shows how the concentration of bromine changes with time.



Which statements is/are true about this reaction?

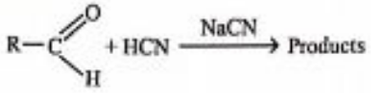
1. the rate of the reaction can be measured by colorimetry
2. half life of the reaction is 200 s
3. the rate expression is: rate = k[Br]

35 A mass of 18.10 g of gaseous ammonia was passed over 90.40 g of solid copper (II) oxide. Nitrogen gas was produced as one of the products.

Which statement(s) is/are true about this reaction.

1. 0.380 moles of nitrogen gas are produced
2. all the copper (II) oxide was used up in the reaction
3. the equation for the reaction is: $2NH_{3(g)} + 3CuO_{(s)} \rightarrow N_{2(g)} + 3Cu_{(s)} + 3H_2O_{(g)}$

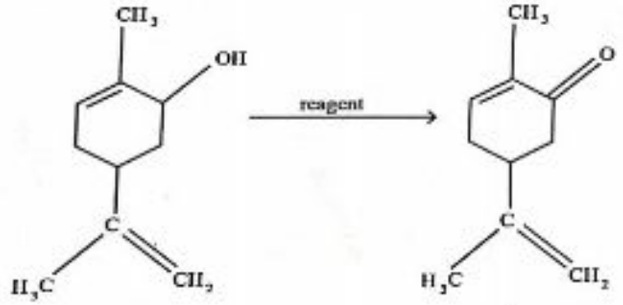
36 The reaction between an aldehyde and HCN is as shown.



Which statement(s) correctly describe(s) what happens during the reaction?

1. A new carbon-carbon bond is formed.
2. In the intermediate complex the oxygen is negatively charged.
3. The last stage involves the formation of a hydrogen-oxygen bond.

37 An organic compound **R** can be converted to **S** as shown.



Which statement(s) about the conversion of **R** to **S** is /are true?

1. the correct reagent is acidified $Na_2Cr_2O_7$
2. the reaction is an elimination reaction
3. the product reacts with Tollen's reagent

38 In the reaction:

$$[Cu(H_2O)_6]^{2+}_{(aq)} + 3en_{(aq)} \rightleftharpoons [Cu(en)_3]^{2+}_{(aq)} + 6H_2O_{(l)}$$

where en = $H_2NCH_2CH_2NH_2$,

the equilibrium constant, K_{stab}, has a value of approximately 5×10^{18} at 25°C.

Which statement(s) explain(s) the significance of the value of the equilibrium constant?

1. $[Cu(en)_3]^{2+}$ ion is more stable than $[Cu(H_2O)_6]^{2+}$ ion
2. en ligand is stronger than H_2O ligand
3. the equilibrium lies more to the right

39 What assumptions are made in Henry's Law?

1. The compound has the same molecular state in both phases.
2. The partition coefficient is constant at constant temperature.
3. The compound should dissolve in both phases.

40 The colour of $[Co(H_2O)_6]^{2+}$ is best attributed to

1. movement of electrons between the metal's d-orbitals.
2. the oxidation state of the metal.
3. the presence of a ligand.

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Ordinary Level

CHEMISTRY PAPER 1 6031/1

NOVEMBER 2018 SUGGESTED ANSWERS AND SOLUTIONS

Question number	key	comment
1	C	There is repulsion between electrons originally in the shells and the incoming ones bin anions.
2	D	
3	D	Polarity of bonds is affected by the differences in electronegativity of the bonding atoms.
4	C	$Cu^{2+} + 2e^- \rightleftharpoons Cu_{(s)} \quad \epsilon^\theta = +0,34$ $M^{2+}_{(aq)} + 2e^- \rightleftharpoons M_{(s)} \quad \epsilon^\theta = -x$ $\Rightarrow \quad M_{(s)} \rightleftharpoons M^{2+}_{(aq)} + 2e^- \quad \epsilon^\theta = -x$ $\therefore \quad 0,34 + (-x) = 0,75$ $0,34 - x = 0,75$ $0,34 - 0,75 = x$ $\underline{-0,410 = x}$
5	C	
6	B	$Ca^{2+}_{(aq)} + SO^{2-}_{4(aq)} \longrightarrow CuSO_{4(s)}$ $Cu^{2+}_{(aq)} + SO^{2-}_{4(aq)} \Rightarrow CuSO_{4(aq)}$ $CuSO_{4(s)}$ is soluble hence filtered from the reaction mixture
7	D	
8	D	
9	B	
10	B	$Co^{3+} + e^- \rightleftharpoons Co^{2+} \quad \epsilon^\theta = 1,82$ $2H_2O \rightleftharpoons O_2 + 4H^+ + 4e^- \quad \epsilon^\theta = -1,23$ $\Rightarrow \quad 4O^{3+} + 2H_2O \longrightarrow 4Co^{2+} + O_2 + 4H^+$ $\epsilon_{\theta u} = 1,82 - 1,23$ $= +0,59$
11	A	

12	B	- SO_2 is an acidic gas - low pH kills microbes
13	D	larger halides form longer bands which are weaker
14	A	Catalytic role of NO_2 in acid rain formation
15	B	write the e.c.f of each element
16	B	
17	B	
18	D	
19	B	the triiodomethane test
20	B	have acid - NH_2 and – COOH group
21	A	diazonium ion decomposes to phenol
22	D	
23	C	
24	A	
25	B	
26	A	draw all possible displayed structured formulae
27	C	alcohol; ester; alkene
28	A	
29	D	
30	A	Carboxyl acid in the organic layer $= 10 - 6{,}5$ $\Rightarrow \frac{\frac{3{,}5}{100}}{\frac{6{,}5}{100}} \quad \frac{[solute]organic}{[solute]aqueous} = 3{,}5\text{g}$ $= \frac{3{,}5}{6{,}5} = \frac{3{,}5}{65}\frac{7}{13} = \underline{0{,}54}$
31	D	
32	B	
33	B	
34	B	
35	A	Construct an equation for the reaction
36	A	1, 2, 3 one true consider the mechanism of reaction
37	D	Oxidation of an alcohol to a ketone
38	A	
39	A	
40	A	Type of ligand, oxidation state, energy levels determine colour of complex ions

Candidate Name	Centre Number	Candidate Number

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL
General Certificate of Education Advanced Level

CHEMISTRY **6031/2**

PAPER 2

NOVEMBER 2018 SESSION 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data Booklet
Mathematical Tables and/or Electronic Calculator

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE	
1	
2	
3	
4	
5	
6	
TOTAL	

Answer all questions

1 (a) A sample of bromine was found to contain 50.52 % of ^{79}Br and the remainder ^{81}Br.

(i) Name the species ^{79}Br and ^{81}Br.

_____

(ii) Define the term *relative atomic mass*.

_____

_____

(iii) Calculate the relative atomic mass of Bromine.

[4]

(b) (i) Write the equation that represents the second ionization energy, of oxygen.

_____

_____

(ii) State and explain any two factors that affect ionization energy of an element.

factor _____

explanation _____

_____

factor _____

explanation _____

_____

[6]

[Total:10]

2 **(a)** **(i)** Define the term *bond energy*.

_____

(ii) Methane reacts with chlorine according to the equation

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl.$$

Calculate the enthalpy change for the reaction.

[4]

(b) **(i)** State **two** factors that affect the magnitude of lattice enthalpy.

1. _____

2. _____

(ii) Explain how the factors in **(b)(i)** affect the magnitude of lattice enthalpy.

_____

_____

_____

_____

_____ [4]

(c) Explain how lattice enthalpy affects solubility of ionic compounds.

_____

_____

_____

_____ [2]

[Total:10]

3 (a) (i) Write the equation for the decomposition of magnesium carbonate.

(ii) State the use of any one of the products from the reaction in (i).

(iii) Describe and explain the trend in the decomposition of Group (II) carbonates.

[3]

(b) Write chemical equations to show how sulphuric acid reacts with

(i) $KBr_{(s)}$.

[2]

(ii) $NaCl_{(s)}$.

[1]

(c) State the observations made in the reaction in

(i) b(i), _____

_____

(ii) b(ii). _____

_____ [2]

[Total:10]

4 (a) Outline how propylamine can be prepared from chloroethane.

_____

_____

_____

_____ [3]

(b) Compare the basicity of propylamine with that of phenylamine.

_____

_____

_____

_____ [2]

(c) (i) Write an equation to show how propylamine dissolves in water.

(ii) State the acid/base nature of the solution formed in (i).

_____ [2]

(d) Superglue contains an organic compound **A**, shown in **Fig.4.1**.

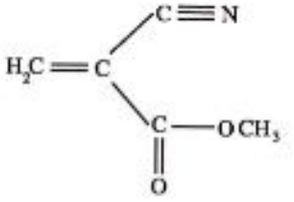


Fig.4.1

(i) Name any **one** functional group in compound **A**.

_____

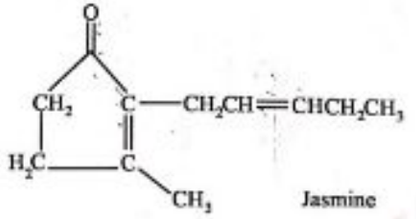
(ii) State the type of polymerization that compound **A** can undergo.

_____

(iii) Draw the repeat unit of the polymer of **A**.

[3]
[Total:10]

5 (a) The structural formula of Jasmine is shown in **Fig.5.1**



Jasmine

Fig.5.1

Draw the structural formula of the organic product formed when Jasmine reacts with

(i) 2,4- dinitrophenylhydrazine,

(ii) $LiAlH_4$,

(iii) cold dilute $KMnO_4$,

(iv) hot, concentrated $KMnO_4$.

[4]

5 (b) (i) State any **two** uses of chlorofluorocarbons.

1. _____

_____

2. _____

_____

(ii) With the aid of equations, explain the detrimental effects of chlorofluorocarbons to the environment.

_____

_____

_____

_____

_____

_____ [5]

[Total:10]

6 (a) **Fig.6.1** shows the apparatus used to separate a mixture of ortho-nitrophenol and para-nitrophenol.

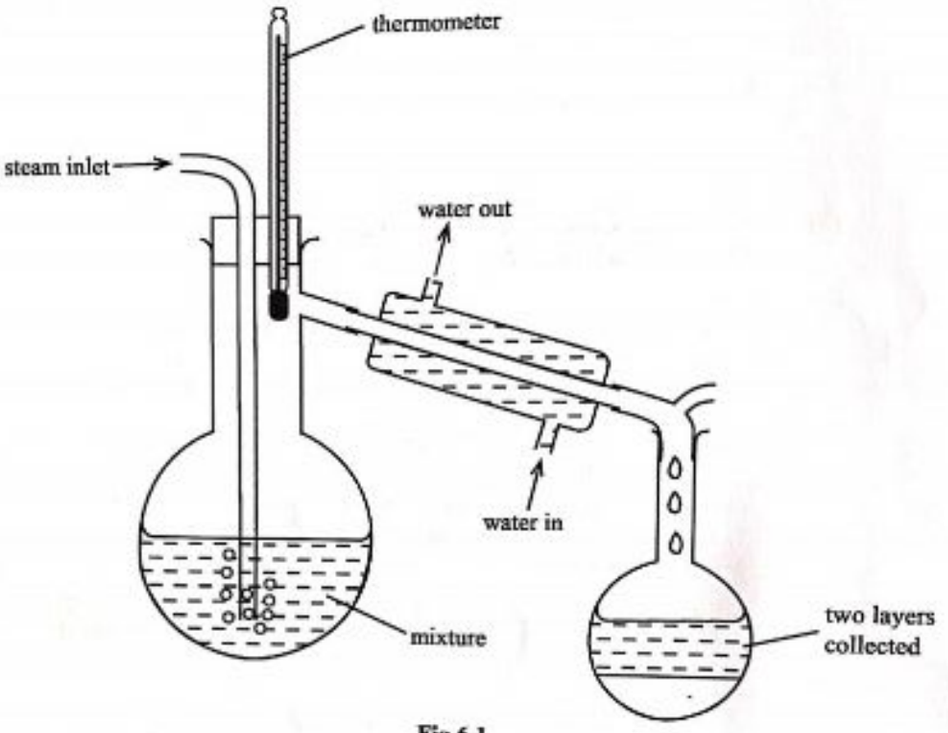


Fig.6.1

(i) Name the separating technique shown.

_____

(ii) State, with reasons, the composition of the distillate.

_____

_____

_____

_____

_____

_____ [6]

(b) Explain the formation in landfills of leachate and methane.

(i) *leachate*

(ii) *methane*

[3]

(c) State **one** problem caused by leachate on the environment.

[1]

[Total:10]

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED SOLUTION ANSWERS

NOVEMBER 2018

CHEMISTRY

6031/2

GTU/02/21 33

1 (a) (i) Isotopes

(ii) The mass of an element compared to $\frac{1}{12}$ of the mass of carbon 12 atoms

(iii) Ar = $\left(\frac{50.52}{100} \times 79\right) + \left(\frac{49,48}{100}\right) \times 81$

= $39.91 + 40.08$

= 79.99

(b) (i) The energy required to remove the second electron from one mole gaseous unipositive ion of oxygen;

$$O^{+}_{(g)} \rightarrow O^{2+}_{(g)} + e^{-} \quad ;$$

(ii) Atomic radius / Shielding effect

The further away from the nucleus the electron, the less attraction by the positive nucleus / outer electrons are shielded by inner electrons from the attractive force of nucleus.

Nuclear charge:
The greater the nuclear charge, the lesser the ionization energy.

2 (a) (i) Amount of heat required to break one mole of covalent bonds in a molecule;

(ii)

Bond broken = $4\,(C-H) + 1\,(Cl-Cl)$

= $4\,(413) + 1(243)$

= $1\,895\ \text{KJ mol}^{-1}$

Bonds made = $3\,(C-H) + 1\,(Cl-Cl) + H-Cl$

= $3\,(413) + 1(346) + 1(432)$

= $2017\ \text{KJ mol}^{-1}$;

ΔH_r = $-2017 + 1895$

= $-1220\ \text{KJ mol}^{-1}$;

(b) (i) Charge on ion;

radius of ion;

comment: Lattice $\propto \frac{Q^+Q^-}{r^+ + r^-}$

(ii) The greater the charge; the stronger the attractive force and the higher the lattice energy produced;

The smaller the radius, the stronger the force of attraction the higher the lattice energy;

comment: $\Delta H_{sol} = -\Delta H_{lattice} + \Delta H_{hydration}$

(c) If lattice energy is higher than hydration enthalpy, the compound does not dissolve;

If lattice energy is lower than hydration energy, the compound dissolve;

3 (a) (i) $MgCO_3 \rightarrow MgO + CO_2$

(ii) MgO – used as lining in furnaces

CO_2 – used in fire extinguishers

(iii) Thermal decomposition decreases down the group;
Cation size increases;
Decreasing polarising power of cation / hence compound becomes more stable

(b) (i) $KBr_{(s)} + H_2SO_{4(l)} \rightarrow HBr_{(g)} + KHSO_{4(s)}$;

$2HBr_{(g)} + H_2SO_{4(l)} \rightarrow Br_{2(g)} + H_2O_{(l)} + SO_{2(g)}$;

(ii) $NaCl_{(s)} + H_2SO_{4(l)} \rightarrow HCl_{(g)} + NaHSO_{4(s)}$

(c) (i) b(i) white fumes and red brown fumes

(ii) white fumes

4 (a) $CH_3CH_2Cl \xrightarrow[reflux]{KCN\ /\ ethanol} CH_3CH_2CN \xrightarrow[ether]{LiAlH_4\ /\ NaBH_4} CH_3CH_2CH_2NH_2$

(b) Propylamine is more basic than phenylamine,
Benzene ring withdraws electrons from nitrogen/ propyl group pushes
Electrons towards nitrogen increasing electron density.

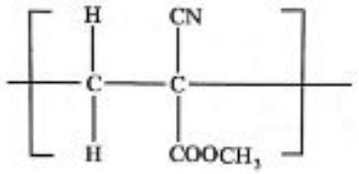
(c) $CH_3CH_2CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2CH_2NH_3^+ + OH^-$

pH 8 – 11

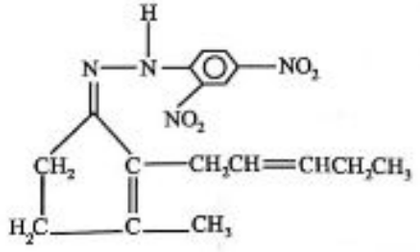
(d) (i) ester/ (C=C) alkene/nitrile

(ii) Addition polymerisation

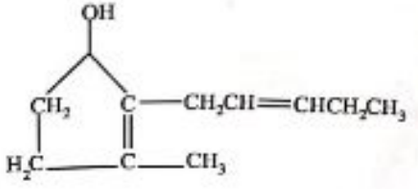
(iii)



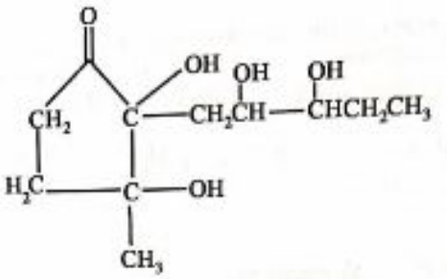
5 (a) (i)



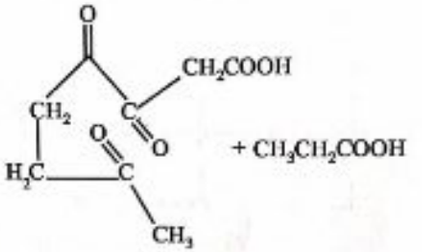
(ii)



(iii)



(iv)



(b) (i) In refrigerators; air conditioning units; solvents in aerosol sprays.

(ii) Destroys ozone layer

$CF_2Cl_2 \xrightarrow{UV} CF_2Cl. + Cl.$

$2ClO. \longrightarrow ClOOCl$

$ClOClO \rightarrow 2Cl. + O_2$

6 (a) (i) Steam distillation

(ii) orthonitrophenol and water mixture
Intramolecular H-bonding in o-nitrophenol,
reduces solubility in water;
increases volatility;
intermolecular H-bonding in p-nitrophenol,
increases molecular weight;
reduces solubility;

(b) (i) Leachate

- Black liquid formed by water which percolates through decomposing organic matter; collecting partly decomposing material and ions

(ii) - Methane – anaerobic decomposition of organic material;

$$2(CH_2O)_{(S)} \rightarrow CH_{4(G)} + CO_{2(g)}$$

(c) Leachate – water pollution / by heavy metal ions or organic matter

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL
General Certificate of Education Advanced Level

CHEMISTRY 6031/3
PAPER 3

NOVEMBER 2018 SESSION 2 hours 30 minutes

Additional materials:
Answer paper
Data Booklet
Mathematical tables and/or electronic calculator

TIME: 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **six** questions.

Answer **two** questions from Section A, **one** question from Section B, **two** questions from Section C and **one** question from Section D.

Write your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Section A

Answer any two questions from this section.

1 (a) **Fig.1.1** shows the mass spectrum of a sample of an element **Y**.

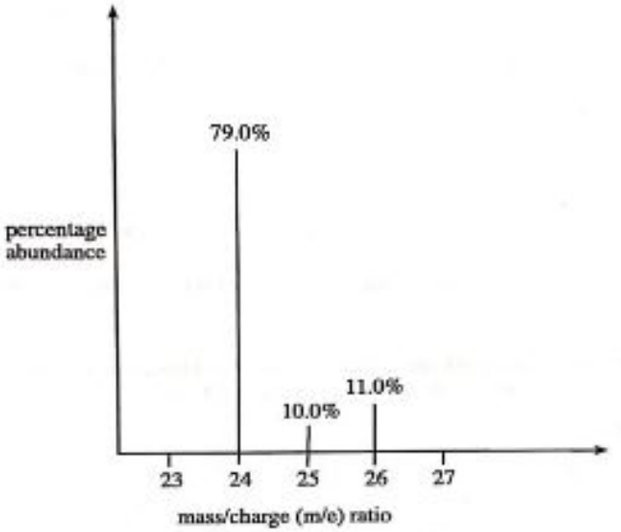


Fig.1.1

(i) Define the term *relative atomic mass.*

(ii) Calculate the relative atomic mass of Y.

(iii) Deduce the full electronic configuration of Y.

(iv) Identify the species responsible for the tallest peak.

(v) Explain why there are three different peaks in the mass spectrum of Y. [6]

(b) (i) Define the term *ionic product of water*, K_w.

(ii) Explain, using K_w, why at 25°C water has a pH of 7. [4]

(c) An aqueous buffer solution containing 0.055 moles of weak acid, HA, and 0.025 moles of NaA in 100 cm^3 of solution has a pH of 4.20.
[K_a of the acid, HA, is 2.87×10^{-5} $moldm^{-3}$ at 25°C]

Calculate the pH of the solution formed when 10 cm^3 of 0.130 $moldm^{-3}$ sodium hydroxide are added to 100 cm^3 of the buffer solution. [5]

[Total:15]

2 (a) Table 2.1 shows enthalpy changes of some chemical processes.

Table 2.1

standard enthalpy of atomisation of magnesium	$+150\ kJmol^{-1}$
first electron affinity of oxygen	$-142\ kJmol^{-1}$
standard enthalpy of formation of magnesium oxide	$-602\ kJmol^{-1}$
lattice enthalpy of magnesium oxide	$-3\,888\ kJmol^{-1}$

(i) Draw a Born-Haber cycle for the formation of magnesium oxide.

(ii) Calculate the second electron affinity of oxygen.

(iii) Explain why

1. the second electron affinity of oxygen is endothermic.

2. magnesium oxide is used as a refractory lining in furnaces.

[8]

(b) In an experiment to determine the rate of reaction between $S_2O_8^{2-}$ and I^- ions, in aqueous solution, the data in **Table 2.2** was obtained.

Table 2.2

experiment number	$[S_2O_8^{2-}]$/ moldm^{-3}	$[I^-]$ moldm^{-3}	initial rate/ moldm^{-3}s^{-1}
1	0.080	0.034	2.2×10^{-4}
2	0.080	0.017	1.1×10^{-4}
3	0.160	0.017	2.2×10^{-4}

(i) Write a balanced ionic equation for the reaction.

(ii) Determine the rate equation.

(iii) Calculate the rate constant, k.

(iv) Suggest an experimental method than can be used to determine the rate of this reaction.

[7]
[Total:15]

3 (a) (i) Write the overall equation of the reaction in a hydrogen-oxygen fuel cell operating under alkaline conditions.

(ii) Calculate the e.m.f. of the cell.

(iii) State one advantage of fuel cells over lead-acid accumulators.

(iv) Explain why the e.m.f. of an acidic hydrogen-oxygen fuel cell is exactly the same as that of an alkaline fuel cell.

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[Total:15]

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(ii) Calculate the e.m.f. of the cell.

(iii) State **one** advantage of fuel cells over lead-acid accumulators.

(iv) Explain why the e.m.f. of an acidic hydrogen-oxygen fuel cell is exactly the same as that of an alkaline fuel cell.

(v) State **one** advantage, other than cost, of using porous coated electrodes in fuel cells.
[use of data from the data booklet is recommended] [5]

(b) A hydrogen-oxygen fuel cell is required to produce a current of 0.03 A for 50 days.

Calculate the mass of hydrogen gas that will be needed. [3]

(c) Sulphur dioxide present in an air sample was dissolved in water. The solution was then titrated against acidified potassium manganate (VII) solution. 7.40 cm^3 of 3.16 gdm^{-3} potassium manganate (VII) solution was required to reach the endpoint.

(i) Construct a balanced chemical equation for the reaction.

(ii) Determine the mass of sulphur dioxide in the air sample.

[7]
[Total:15]

Section B

*Answer **one** question from this section.*

4 **(a)** Describe and explain

1. how the melting points of Group (II) elements vary down the group,

2. the trend in the decomposition temperatures of Group (II) nitrates. [6]

(b) Hydrogen sulphide is produced when concentrated sulphuric acid is added to solid sodium iodide but sulphur dioxide is produced when concentrated sulphuric acid is added to solid sodium bromide.

(i) State, with reasons, the halide ion that has a greater reducing power.

(ii) Write an equation for the formation of

1. sulphur dioxide,

2. hydrogen sulphide.

(iii) In addition to sulphur dioxide and hydrogen sulphide, another reduction product is formed in the reactions in **(b)**.

1. Name the reduction product.

2. Deduce a half equation for its formation. [9]

[Total:15]

5 **(a)** **(i)** Compare the solubilities of MgO and CaO in water.

(ii) Explain why Group (II) metals are suitable for use in fireworks. [4]

(b) Explain the

(i) variation in volatility of Group (VII) elements,

(ii) trend in the thermal stabilities of Group (VII) hydrides. [6]

(c) LoSalt is a mixture of sodium chloride and potassium chloride.

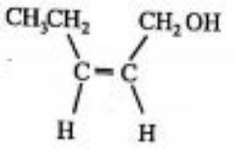
Describe and explain how the total concentration of chloride in LoSalt can be determined. [5]

[Total:15]

Section C

Answer any two questions from this section.

6 **Fig.6.1** shows the structure of an organic compound **C**.



compound **C**

Fig.6.1

(a) Draw the structure of the organic product formed when **C** reacts with

(i) a solution of bromine in tetrachloromethane,

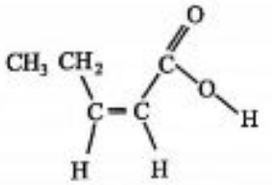
(ii) CH_3COOH in the presence of an acid catalyst. [2]

(b) Compounds **D** and **E** were formed when **C** was reacted with HBr.

(i) Draw structures of **D** and **E**.

(ii) Explain how **D** and **E** are related. [3]

(c) **Fig.6.2** shows the structure of a compound **F** that can be prepared from compound **C**.



F

Fig.6.2

(i) Suggest reagents for the conversion of **C** to **F**.

(ii) Identify the intermediate for the reaction in c **(i)**.

(iii) Describe how the intermediate can be removed from the reaction mixture.

(iv) State the type of reaction that produces the intermediate. [4]

(d) (i) Describe the bonding in benzene in terms of sigma and pi bonds.

(ii) Outline the mechanism for the reaction of benzene with $Cl_{2(g)}$ in the presence of $FeCl_3$ catalyst.

[6]
[Total:15]

7 **Fig.7.1** shows a reaction pathway of a polymer.

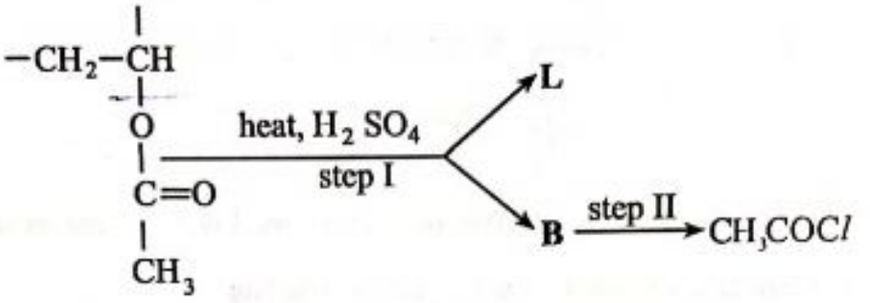


Fig.7.1

(a) (i) Draw the structural formula of

1. the monomer from which the polymer was made,
2. **L**,
3. **B**.

(ii) Identify any **two** functional groups in the monomer.

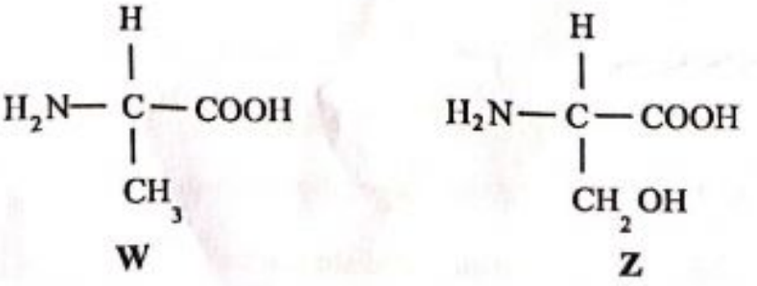
(iii) The polymer was reacted with excess sodium hydroxide to form another polymer.

Draw the repeat unit of the new polymer.

(iv) Give reagents and conditions for step II.

[9]

(b) **Fig.7.2** shows the structure of two organic comppounds, **W** and **Z**,



(i) Draw the structure of

1. the compound formed when **W** and **Z** react in aqueous solution.
2. W in a neutral aqueous solution.

(ii) Explain the amphoteric behaviour of **W**.

(iii) State, with reasons, which compound, **W** or **Z**, will form enantiomers.

[6]
[Total:15]

8 (a) The synthesis of 3 - nitrophenylamine is shown in **Fig. 8.1**.

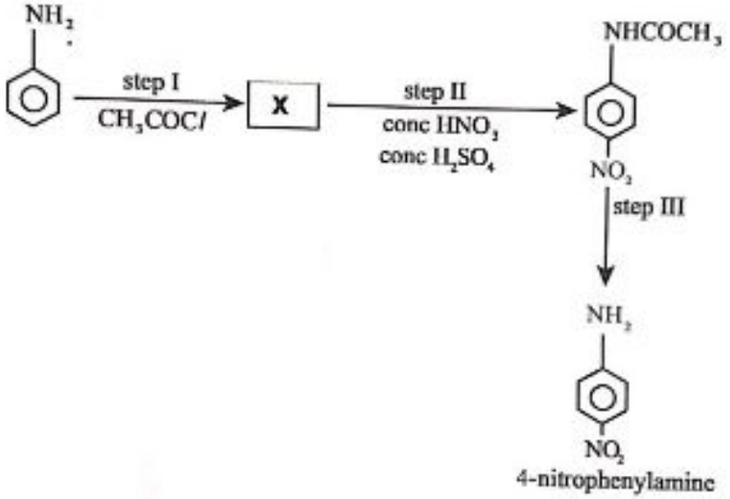


Fig. 8.1

(i) Draw the structure of **X**.

(ii) Name and outline a mechanism for step II.

(iii) Deduce the type of reaction for step III.

(iv) State the reagents and conditions for step III.

[7]

(b) Describe a two step reaction scheme for the formation of phenylamine from benzene. [3]

(c) An organic compound of molecular formula C_4H_8O gave an orange precipitate in the presence of 2,4- DPNH. The compound did not give an observable change when treated with acidified $K_2Cr_2O_7$.

Deduce, with reasons, the

(i) functional group(s) present in the compound,

(ii) possible structural formula of the compound.

[5]

[Total:15]

Section D

Answer **one** question from this section.

9 **(a)** Outline the **six** steps involved in the production of a genetic fingerprint. [3]

(b) One of the steps in **(a)** involves the use of a radioactive isotope.

(i) Name the isotope used.

(ii) State **one** reason why this isotope is chosen. [2]

(c) State any **two** factors that affect the speed at which amino acids move towards an electrode during electrophoresis. [2]

(d) **Fig.9.1** shows the results of the electrophoresis of a mixture of four acids, K, L, M and N, at a known pH.

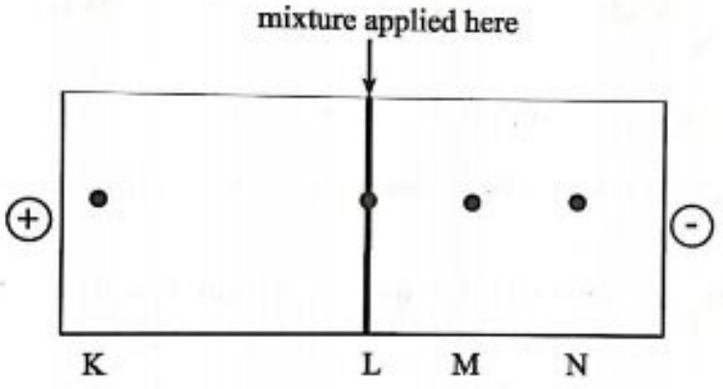
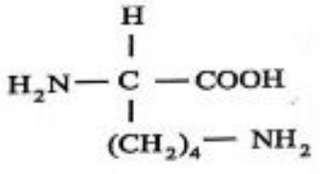
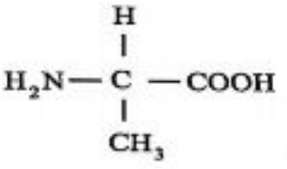


Fig.9.1

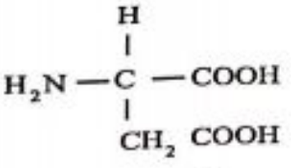
The amino acids that were present in the mixture are shown in **Fig.9.2**.



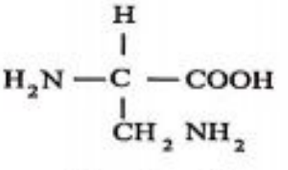
lysine



alanine



aspartic acid



glutamic acid

Fig.9.2

(i) Identify, with reasons, the amino acids K, L, M and N. [4]

(ii) In each case draw the structure of the amino acid as it appears at this pH. [4]

[Total:15]

10 (a) Modern catalytic converters consist of compacted nano particles coated with Pt/Rh catalyst.

(i) Explain the advantage of making the catalytic converter using nano particles.

(ii) State the type of catalysis that occurs in the catalytic converter.

(iii) Explain how Pt/ Rh function as a catalyst.

(iv) Write an equation for the reaction that occurs in the catalytic converter. [8]

(b) (i) State the origin of sulphur in fossil fuels.

(ii) Write an equation for the formation of sulphur dioxide in thermal power stations.

(iii) Describe the detrimental effects of sulphur dioxide in the atmosphere.

(iv) Explain with the aid of equations, two methods used to minimise the release of sulphur dioxide into the atmosphere at a thermal power station. [7]

[Total:15]

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED ANSWERS AND SOLUTIONS

NOVEMBER 2018

CHEMISTRY **6031/3**

1 (a) (i) Average mass of one atom of the element compared to $\frac{1}{12}$ of the mass of one atom of C_1= 12 isotope/

$$A_r = \frac{12 \times \text{average mass of one atom of an element}}{\text{mass of one atom of C-12}}$$

(ii) $$\frac{79.0 \times 24 + 10.0 \times 25 + 11.0 \times 26}{100}$$

$= 24.3$

(iii) $1S^2\ 2S^2\ 2P^6\ 3S^2$

(iv) $^{24}Y^{+}$

(v) Y has three different isotopes

(b) (i) the equilibrium constant for the reaction in which water undergoes an acid base reaction with itself;

(ii) $H_2O \rightleftharpoons H^+ + OH^-$;

$K_w = [OH^-]\ [H^+] = 1 \times 10^{-14}$

$[OH^-] = [H^+]; = 1 \times 10^{-7}$

$pH = -\log(10^{-7}) = 7$;

(c) No of moles of NaOH $= \frac{10 \times 0{,}130}{1\,000}$

$= 0{,}0013$;

No of moles of HA remaining $= 0{,}055 - 0{,}0013/$

$= 0{,}0537$;

No of moles of A^- present $= 0{,}025 + 0{,}0013/$

$= 0{,}0263$;

$$pH = pKa + \log\frac{[salt]}{[Acid]}$$

$$= -\log(2{,}87 \times 10^{-5}) + \log\left(\frac{0{,}0263}{0{,}0537}\right)$$

$= 4{,}23$

2 (a) (i) correct a Born-Haber cycle showing all the stages for the formation of magnesium oxide.

(ii) $\Delta H2^{nd}EA = -602 - (150 + 248 + 736 + 1\,450 - 142 - 3\,888)$;

$+844\ k\ Jmol^{-1}$;

(iii) 1 O^{-1} repels the incoming electron;

more energy required to overcome the repulsion;

2 it has a high melting point due to strong electrostatic forces between ions.

(b) (i) $S_2O_8^{2-} + 2I^- \rightarrow 2SO_4^{2-} + I_2$;

(ii) Comparing experiments 1 and 2

$[I^-]$ is halved while $[S_2O_8^{2-}]$ is kept constant, rate is also halved. Hence,

order is 1 with respect to I^-.

Comparing experiments 2 and 3
$[S_2O_8^{2-}]$ is doubled, while $[I^-]$ is kept constant, rate is also doubled.
Hence order is 1 with respect to $S_2O_8^{2-}$;

Rate = $k\,[S_2O_8^{2-}][I^-]$;

(iii) $k = \frac{rate}{[S_2O_8^{2-}][I^-]}$

$= \frac{2,2\times10^{-4}}{0,080\times0,034}$

$= 8,1 \times 10^{-2}$; $mol^{-1}dm^3s^{-1}$;

(iv) Colorimetric /titrimetric

3 (a) (i) $O_2 + 2H_2O + 4e^- \leftrightharpoons 4OH^-$ $\epsilon^\theta = 0,40v$
$2H_2O + 2e^- \leftrightharpoons H_2 + 2OH^-$ $\epsilon^\theta = -0,83v$

[use equations / data from the data booklet]

Overall reaction : $2H_2 + O_2 \rightarrow 2H_2O$;

(ii) $E^\theta_{cell} = 0,83 + 0,40 = +1,23V$;

(iii) - Perpetual supplier of electricity while lead – acid accumulators / have to be charged;

- Minimises pollution /

(iv) Overall reaction is the same ($2H_2 + O_2 \rightarrow 2H_2O$)

(v) Increase the surface area; (so reaction is faster)

(b) Charge passed = $0,03 \times 50 \times 24 \times 60 \times 60$

= 129600 c;

$n(H_2) = \frac{1 \times t}{2 \times 96500}$

$= \frac{129600}{2 \times 96500}$

= 0,6715 mol;

mass
$m(H_2) = 0,6715 \times 2$

= 1,34 g

(c) (i) $SO_2 + 2H_2O \rightarrow SO_4^{2-} + 4H^+ + 2e^-$

$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$;

$5\,SO_2 + 2MnO_4^- + 2H_2O \rightarrow 5SO_4^{2-} + 2Mn^{2+} + 4H^+$

(ii) $M_r(KMnO_4) = 39,1 + 54,9 + 4\,(16)$

= 158

$[KMnO_4] = \frac{3,16}{158} = 0,02\ moldm^{-3}$

$n(MnO_4^-) = \frac{7,4}{1000} \times 0,02 = 1,48 \times 10^{-4}$ mol

$n(SO_2) = \frac{15}{2} \times n(MnO_4^-)$

$= \frac{5}{2} \times 1,48 \times 10^{-4}$

$= 3,7 \times 10^{-4}$mol

$M_r(SO_2) = 32,1 + 2(16) = 64,1$

$m(SO_2) = n \times Mr$

$= 3{,}7 \times 10^{-4} \times 64{,}1$

$= 2{,}37 \times 10^{-2}$g

4 (a) 1 Melting points decrease down the group;
going down the group there is decrease in metallic bond due to in crease in atomic size;
hence causing the decrease in attraction between the positive nuclei and delocalised electrons;

2 Decomposition temperatures increase down the group;

Charge density of group II cations decreases;

- Polarisation of NO_3^{2-} ion decreases;

(b) (i) Iodide/ I^-

Iodide reduces S from +6 in H_2SO_4 to −2 in H_2S

Bromine reduces sulphur from +6 in H_2SO_4 to +4 in SO_2.

(ii) 1. $NaBr + H_2SO_4 \rightarrow NaHSO_4 + HBr$

$2HBr + H_2SO_4 \rightarrow Br_2 + SO_2 + 2H_2O$

Overall: $2NaBr + 3H_2SO_4 \rightarrow 2NaHSO_4 + Br_2 + SO_2 + 2H_2O$

2. $SO_4^{2-} + 8H^+ + 8e^- \rightarrow H_2S + 4H_2O$

$2I^- \rightarrow I_2 + 2e^-$

(iii) 1. Sulphur

2. $H_2SO_4 + 6e^- \rightarrow S + 4H_2O$

5 (a) (i) MgO slightly soluble in water,

CaO readily dissolves in water;

(ii) burn readily in O_2 to produce bright / coloured flames;

(b) (i) - Volatility decreases from F_2 to I_2;

- Strength of Van der Waals; increases with increase in electron cloud;

(ii)

Hydride	Bond Energy/k Jmol^{-1}
H – F	562
H – Cl	431
H – Br	366
H – I	299

- Thermal stability decreases from HF to HI;
- HX becomes easier to break down the group as bond energy decreases;

(c) - Weigh out accurately a known mass (xg) of LoSalt;
Dissolve in 25cm^3 of distilled water add in a 250.00 cm^3 volumetric flask and add up to the mark;
Add excess silver nitrate solution to the conical flask;
Titrate with KCN using aqueous Fe^{3+} ion as indicator;
Until a dark red colour appears;

Excess Ag^+ ions react with the CN^- ions when all Ag^+ ions have reacted the remaining CN^- ions will react with Fe^{3+} ions to form a dark red complex.

6 (a) (i) $CH_3\ CH_2\ CHB_r\ CHB_r\ CH_2\ OH$;

(ii) $CH_3\ CH_2\ CH\ CH\ CH_2O_2CCH_3$;

(b) (i) $CH_3\ CH_2\ CH_2\ CHB_r\ CH_2OH$; $CH_3\ CH_2\ CHB_r\ CH_2\ CH_2OH$;
D E

(ii) Structural isomers;

(c) (i) $K_2Cr_2\ O_2$ and $H_2\ SO_4$;

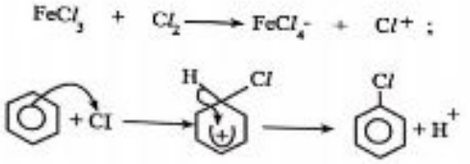
(ii) $CH_3\ CH_2\ CH\ CH\ CHO$;

(iii) distillation;

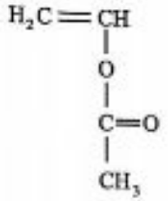
(iv) (partial) oxidation;

(d) (i) C – C; σ
C – C; π
C – H; σ

(ii)



7 (a) (i) 1.



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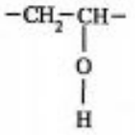

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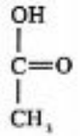
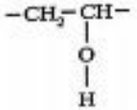


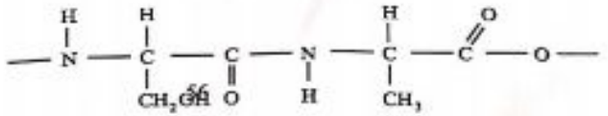
(ii) c – c double bond/ c = c/ alkene; ester;

(iii)



(iv) PCl_5

(b) (i) 1.



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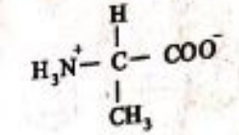


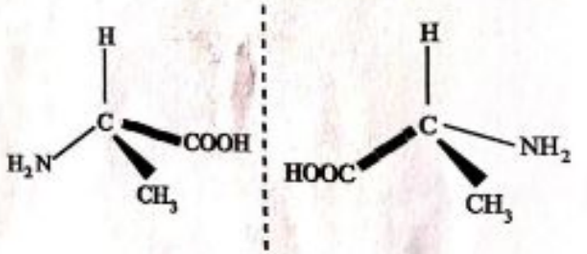
(ii) In acidic solution NH_2/COO^- group accepts a proton;

In alkaline solution $COOH/ NH_3^+$ group donates a proton;

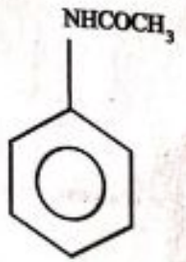
(iii) Both W and Z;

Carbon atom surrounded by four different substituents;

1. Optical

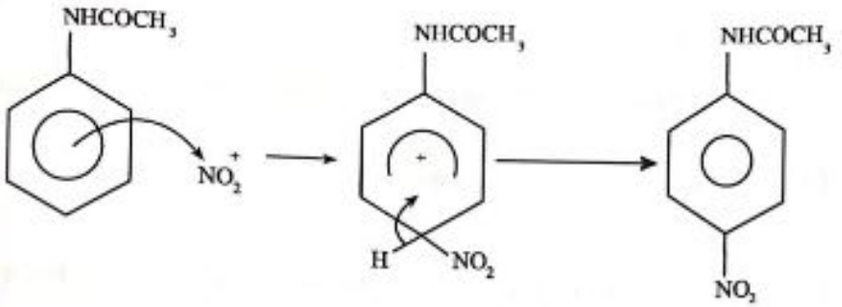


8 (a) (i)



(ii) electrophilic substitution;

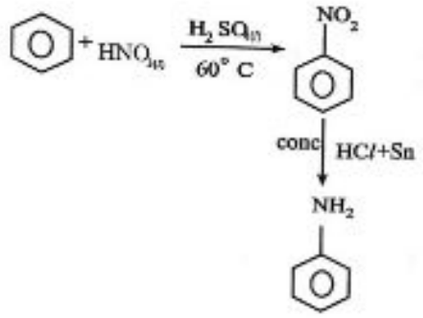
$$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ 2HSO_4^-$$



(iii) alkaline hydrolysis;

(iv) $NaOH_{(aq)}$, warm;

(b)



(c) $CH_3 - CO - CH_2 - CH_3$; /
reacted with 2,4-DPNH;
but no oxidation occurred with acidified $K_2Cr_2O_7$

9 (a) (i) Extract DNA

(ii) Use restriction enzyme

(iii) Use polymerase chain reaction

(iv) Place samples on agarose gel / carry out electrophoresis

(v) Compare the DNA bands of the sample

(vi) label with a radio active isotope

(b) (i) Phosphorus – 32

(ii) It makes the DNA fragments/bands visible/ it binds to phosphate groups of DNA

(c) Size of the ions/ charge on the ions/ voltage/ temperature/ pH/

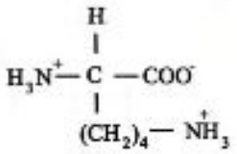
(d) (i) K is Aspatic. It moved to the furthest positive electrode. Therefore, it is charged negatively;

L is alanine. It does not move because the pH of the solution is the same as its isoelectric point/ exists as a zwitterion;

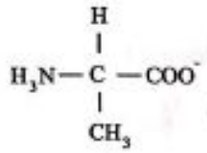
M is lysine acid. moves to the negative electrode; it is positively charged; has a bigger M_r than glutamic acid

N is acid glutamic; move to the negative electrode; it is positively charged; has a smaller M_r compared to lysine

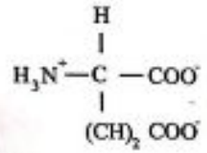
(ii)



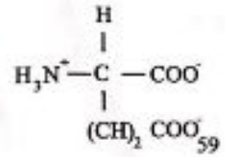
lysine(k)



alanine(L)



glutamic acid(M)



aspartic acid(N)

10 (a) (i) Nanoparticles increase surface area; reaction rate is faster;

rapid adsorption of gases from exhaust fumes;

(ii) Heterogenous catalysis;

(iii) Pt and Rh have partially filled d-orbitals;

that form weak bonds with the adsorbed gases;

the bonds in reactant molecules are weakened;

and activation energy for the reaction is lowered;

(iv) $2CO + 2NO \rightarrow 2CO_2 + N_2$;
$2CO + NO_2 \rightarrow 2CO_2 + \frac{1}{2}N_2$;
$4CO + 2NO_2 \rightarrow 4CO_2 + N_2$;

(b) (i) proteins/ organic matter;

(ii) $S_{(s)} + O_{2(g)} \rightarrow SO_{2(g)}$; / Ca(OH) + SO

(iii) SO_2 causes acid rain;

(iv) Alkaline scrubbing;

$CaO_{(s)} + SO_{2(g)} \rightarrow CaSO_{3(s)}$ $/Ca(OH)_2 + SO_{2(g)} \rightarrow + CaSO_4 + H_2O$;

Fluidised bed desulphurisation

$CaCO_3 + SO_2 \rightarrow + CaSO_3 + CO_2$;

$\left(CaSO_3 + \frac{1}{2}O_2 \rightarrow CaSO_4\right)$

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Ordinary Level

CHEMISTRY

6031/4

Paper 4 Practical Test

2 hours 30 minutes

NOVEMBER 2018

Identities of chemicals required

FA2 is made by mixing sodium hydrogen carbonate and soluble starch in the ratio 1:1 by mass. Mix thoroughly to form a homogenous mixture.

FA3 is 0.1 $moldm^{-3}$ nitric acid

FA4 is a homogeneous mixture of 30 g manganese (II) chloride and 20 g sodium nitrate dissolved in 1 dm^3 distilled water.

FA5 is 0.1 $moldm^{-3}$ NaOH

1 You are required to determine the amount of an acidic sodium salt present in a sample of baking powder, **FA1**, using a titration method.

FA1 is a sample of the baking powder
FA3 is 0.1 moldm^{-3} nitric acid

(a) Weigh between 4.50 g and 4.80 g of **FA1** into a 100 cm^3 beaker.

Record the weighings in **Table 1.1.**

Table 1. 1

mass of beaker + **FA1**/g	
mass of empty beaker/g	
mass **FA1** measured/g	

[2]

Add 50 cm^3 of distilled water from a measuring cylinder into **FA1** in the beaker.

Stir the mixture using a glass rod. Leave to stand for two minutes.

Decant into a mounted filter paper collecting the filtrate into a 250 cm^3 volumetric flask.

Add another 50 cm^3 of distilled water into the beaker with the residue and repeat the filtration procedure.

Top up the filtrate to the mark with distilled water. Label this solution **FA2.**

(b) Pipette 25.0 cm^3 **FA2** into a 250 cm^3 conical flask.

Add 3 drops of methyl orange and titrate the mixture with **FA3.**

Repeat the titration to obtain accurate results.

Table 1.2 Titration of FA2 with FA3

Titration number	**1**	**2**	**3**	**4**
Final burette reading /cm^3				
Initial burette reading/cm^3				
The volume of **FA3** used / cm^3				

_____ cm^3 of **FA2** is required to react completely

with _____ cm^3 **FA3**.

(c) Calculate the number of moles of nitric acid in the average titre.

(d) Deduce the number of moles of acidic sodium salt present in 25 cm^3 of **FA2** given that nitric acid reacts with the acidic sodium salt in the ratio 1:1.

(e) Calculate the number of moles of the acidic sodium salt present in **FA1**.

(f) The relative molecular mass, M_r, of the acidic sodium salt is 84.01. Calculate the percentage of the acidic sodium salt present in **FA1**.

2 Carry out the following tests to determine the identities of the ions present in **FA4**.

In all the tests, reagents should be added gradually until no further change occurs, with shaking after each addition.

Observations should include;

(i) descriptions of colour changes and precipitates

(ii) the names of gases evolved and details of the test used to identify them.

You should indicate clearly at what stage in the test a change occurs, writing any deductions you make alongside the observations on which they are based.

No additional or confirmatory tests for ions present should be attempted.

test	observations	deductions
(a) To a portion of **FA4** add aqueous sodium hydroxide until excess		
(b) To a portion of **FA4** add aqueous ammonia until excess		
(c) To a portion of **FA4** add dilute nitric acid followed by aqueous silver nitrate		

Test	Observations (10)	Deductions (5)
(d) To a portion of **FA4** add aqueous lead (II) nitrate boil the mixture		
(e) To a portion of **FA4** add dilute hydrochloric acid followed by aqueous barium chloride		
(f) To a portion of **FA4** add aqueous sodium hydroxide and aluminium foil warm the mixture cautiously		

Conclusions

FA4 contains the cation _____ and

anions _____ and _____

Assessment of Planning Skills

DO NOT CARRY OUT YOUR PROCEDURE

3 You are required to investigate the relationship between current passing through the electrolyte and the amount of substance deposited on the cathode.

Assume you are provided with:

carbon rods
10 g solid copper (II) sulphate
3 (1.5V) electric cells
connecting wires
balance
clock
100 cm^3 beaker
digital ammeter
distilled water

Devise a sequence of numbered steps to show how the relationship between current passing through the electrolyte and amount of substance deposited on the cathode can be investigated.

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED SOLUTIONS

NOVEMBER 2018

CHEMISTRY

6031/4

1 (a) **Table 1.1**
All readings to 2 decimal places

value within range 4,50 < mass < 4,80

(b) **Table 1.2**

All recording to 2 decimal places and all value ending with either 0 or 5

At least two titre values with 0,1 difference and correct subtraction

Values with 0,1 difference ticked,
average calculation shown
summary completed to 2 decimal places ending with either 0 or 5.

Accuracy value calculation

$$\text{Diff} = \left(\frac{\text{Mass measured by supervisor}}{\text{supervisor's titre}}\right) - \left(\frac{\text{Mass measured by candidate}}{\text{candidate's titre}}\right)$$

(c) $\frac{\text{titre} \times 0{,}1}{1\,000}$ / $dm^3 \times 0{,}2$

(d) answer to (c)

(e) Answer to (c) or (d) x 10] $\frac{250}{25}$

Evaluation answer to 3 s.f.
or standard form

(f) Answer to (e) x Mr (acidic Sodium salt) = Mass of acid salt.

$$\frac{\textit{Mass of acidic sodium salt}}{\textit{mass of FA1 measured}} \times 100\%$$

2 (a) Off white ppte insoluble
turn to brown on top — Mn^{2+}

(b) Off white ppte insoluble
turn brown on top — Mn^{2+}

(c) No effervescence/
No observable change — No CO_3^{2-}, NO
NO_2^- and SO_3^{2-}

White ppte — Cl^-

(d) White ppte — Cl^- confirmed

(e) No effervescence
No ppte

No CO_3^{2-}.
NO_2^- and SO_3^{2-}
NO Ba^{2+} (l) or
Pb^{2+}

No SO_4^{2-}

no ppte/ no observable change

NO_3^-

(f) a gas (ammonia) produced
which turns damp red litmus paper blue/
choking/ pungent smelling gas

Cation Mn^{2+}

Anions Cl^- and NO_3^-

3 (a) Using a balance, measure the mass of carbon rods

(b) Weigh between 2g and 3.3g of copper (II) sulphate using a balance

(c) Dissolve the copper (II) sulphate in 40 cm^3 of distilled water (volume of distilled water range 30 cm^3 to 70 cm^3.

(d) Place the solution into a 100 cm^3 beaker

(e) Using the connecting wires suspend the copper rods into the copper (II) sulphate solution

(f) Complete the circuit by connecting the digital ammeter, 1 cell and allow current to flow for a certain time *(t)*

(g) After time (*t*) disconnect the circuit, collect the carbon rods, rinse, dry and measure the mass of the carbon rods using a balance

(h) Measure the same mass of copper (II) sulphate as in **(b)**
use another set of carbon rods
and repeat the experiment using 2 cells

(i) Repeat the experiment the third time using 3 cells

(j) Compare the increase in mass of the cathode for the 3 experiments

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

CHEMISTRY 6031/1

PAPER 1 Multiple Choice

JUNE 2019 SESSION 1 hour

Additional materials:
- Data Booklet
- Scientific/Electronic calculator
- Multiple Choice answer sheet
- Soft pencil (type B or HB is recommended)

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has already been done for you.

There are **forty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

Read very carefully the instructions on the answer sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score **one** mark. A mark will **not** be deducted for a wrong answer.
Any rough working should be done in this booklet.

*For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider to be correct.*

1 Which substance must be separated from chlorine by the diaphragm during the electrolysis of brine?

A hydrogen
B sodium chloride
C sodium hydroxide
D water

2 Bromine reacts with hot concentrated alkali as shown in the equation.

$$3Br_{2(l)} + 6OH^-_{(aq)} \longrightarrow 5Br^-_{(aq)} + BrO^-_{3\,(aq)} + 3H_2O_{(l)}$$

The oxidation state of bromine changes from zero to

A − 1 and +3.
B − 1 and +5.
C − 1 and +7.
D +1 and +7.

3 Which equation correctly defines the standard enthalpy change of formation of hydrogen cynide, HCN?

A $H_{(g)} + C_{(s)} + N_{(g)} \longrightarrow HCN_{(g)}$

B $\frac{1}{2}H_{2(g)} + C_{(s)} + \frac{1}{2}N_{2(g)} \longrightarrow HCN_{(g)}$

C $H_{2(g)} + 2C_{(l)} + N_{2(g)} \longrightarrow 2HCN_{(g)}$

D $\frac{1}{2}H_{2(g)} + C_{(l)} + \frac{1}{2}N_{2(g)} \longrightarrow HCN_{(g)}$

Section A

*For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider to be correct.*

1 Which substance must be separated from chlorine by the diaphragm during the electrolysis of brine?

A hydrogen
B sodium chloride
C sodium hydroxide
D water

2 Bromine reacts with hot concentrated alkali as shown in the equation.

$$3Br_{2(l)} + 6OH^-_{(aq)} \longrightarrow 5Br^-_{(aq)} + BrO^-_{3\,(aq)} + 3H_2O_{(l)}$$

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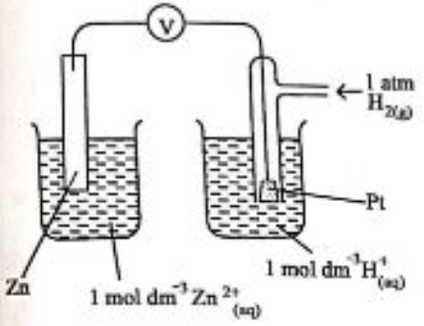
B $\frac{1}{2}H_{2(g)} + C_{(s)} + \frac{1}{2}N_{2(g)} \longrightarrow HCN_{(g)}$

C $H_{2(g)} + 2C_{(l)} + N_{2(g)} \longrightarrow 2HCN_{(g)}$

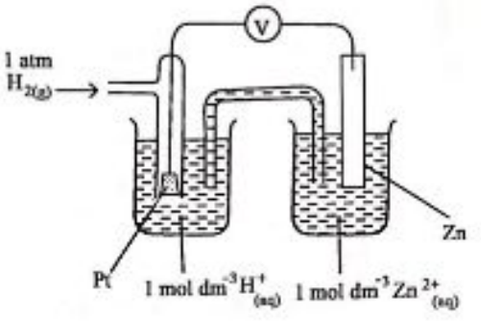
D $\frac{1}{2}H_{2(g)} + C_{(l)} + \frac{1}{2}N_{2(g)} \longrightarrow HCN_{(g)}$

4 Which diagram correctly shows how the standard hydrogen electrode is used to measure the E^{θ} of a zinc cell?

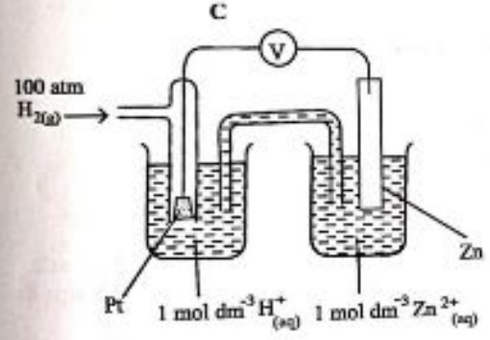
A



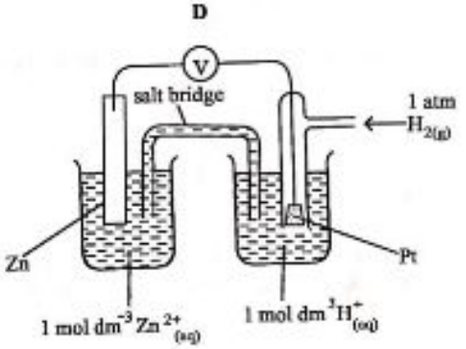
B



C



D



5 What are the anodic products when $NaBr_{(l)}$ and $CuF_{2(aq)}$ are electrolysed using inert electrodes?

A $Br_{2(g)}$ and $O_{2(g)}$
B $O_{2(g)}$ and $H_{2(g)}$
C $Br_{2(g)}$ and $F_{2(g)}$
D $Na_{(s)}$ and $F_{2(g)}$

6 The results shown were obtained for a reaction between **X** and **Y**.

concentrations/moldm^{-3}		initial rate/moldm$^{-3}s^{-1}$
[X]	[Y]	
0.5	1.0	2
0.5	2.0	8
0.5	3.0	18
1.0	3.0	36
2.0	3.0	72

What is the rate equation for the reaction?

A k [Y]
B k[X] [Y]^2
C k[X]^2[Y]
D k[X][Y]

7 What are the units for the rate constant of a second-order reaction?

A moldm^{-3}s^{-1}
B mol^{-1}dm^{3}s^{-1}
C mols^{-1}
D s^{-1}

8 An excess of KI solution was added to a 25 cm^3 sample of a solution of a copper (II) salt. The liberated iodine required 15 cm^3 of 0.01 mol dm^{-3} sodium thiosulphate to discharge its colour.

What is the concentration of Cu^{2+} in the sample?

A 0.000006 mol dm^{-3}
B 0.00015 mol dm^{-3}
C 0.003 mol dm^{-3}
D 0.006 mol dm^{-3}

9 The reaction of acidified aqueous potassium iodide with aqueous hydrogen peroxide

$2I^-_{(aq)} + H_2O_{2(aq)} + 2H^+_{(aq)} \rightarrow I_{2(aq)} + 2H_2O_{(l)}$, is thought to involve the following steps:

$H_2O_2 + I^- \longrightarrow H_2O + OI^-$ (slow)
$OI^- + H^+ \longrightarrow HOI$ (fast)
$HOI + H^+ + I^- \longrightarrow I_2 + H_2O$ (fast)

Which statement about the reaction, is **not** true?

A The acid acts as a catalyst.
B The reaction is first order with respect to the iodide ion.
C The iodide ion is oxidised by the hydrogen peroxide.
D The overall order of the reaction is 2.

10 The value of the solubility product of Ag_2CO_3 is 2×10^{-8}.

What is the concentration of silver ions in Ag_2CO_3?

A 7.10×10^{-5}
B 1.00×10^{-4}
C 1.71×10^{-3}
D 3.42×10^{-3}

11 An element, X, forms both a dichloride XCl_2 and a tetrachloride XCl_4. Treatment of 10.00 g of XCl_2 with excess $Cl_{2(g)}$ forms 12.55 g of XCl_4.

What is element X?

A Pb
B Sn
C Ge
D Si

12 Berylium compounds are covalent due to

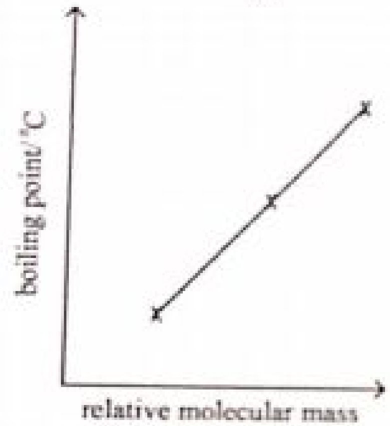
A low polarising power and large size of the berylium ion.
B low polarising power and small size of the berylium ion.
C high polarising power and large size of the berylium ion.
D high polarising power and small size of the berylium ion.

13 Which pair of oxides will give a solution with a very high pH?

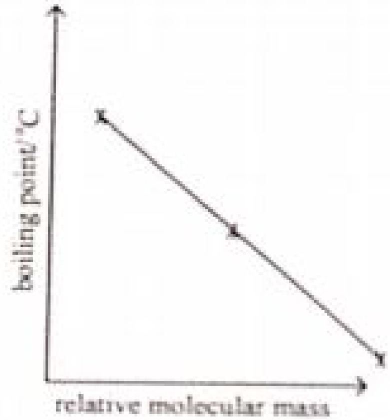
A Al_2O_3 and MgO
B Na_2O and MgO
C Na_2O and P_4O_{10}
D SO_3 and P_4O_{10}

14 Which graph correctly shows the variation of the boiling points of $SiCl_4$, $GeCl_4$ and $SnCl_4$?

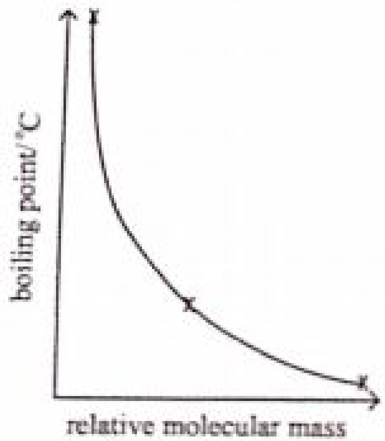
A



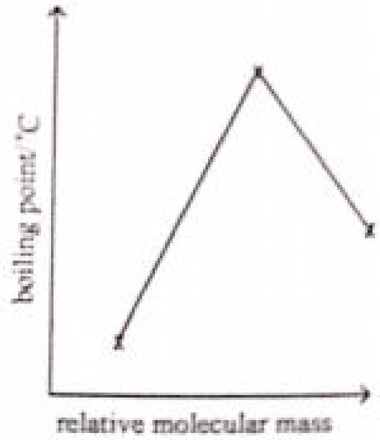
B



C



D



15 Which statement explains the difference in thermal stabilities of calcium nitrate and barium nitrate?

A The lattice energy of calcium nitrate is smaller than that of barium nitrate.
B The ionic radius of the calcium ion is larger than that of the barium ion.
C The ionisation energy of calcium is greater than that of barium.
D The calcium ion has a greater charge density than that of barium.

16 The pH of solution R was found to be 3 and the pH of another solution T was found to be 6.

It can be concluded that

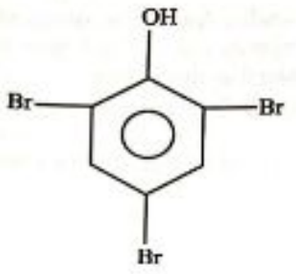
A $[H^+]$ in solution R is half that of $[H^+]$ in solution S.
B $[H^+]$ in solution R is double that of $[H^+]$ in solution S.
C $[H^+]$ in solution R is 1×10^3 times that of $[H^+]$ in solution S.
D $[H^+]$ in solution R is 1×10^{-3} times that of $[H^-]$ in solution S.

17 Which reagent could be used to distinguish between $CH_3CH(OH)CH_2CHO$ and $CH_3COCH_2CH_2OH$?

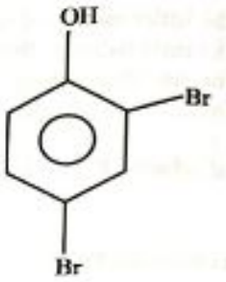
A 2,4-dinitrophenylhydrazine
B acidified potassium dichromate (VI)
C sodium carbonate
D Fehling's reagent

18 Phenol reacts with excess bromine at room temperature to produce

A



B



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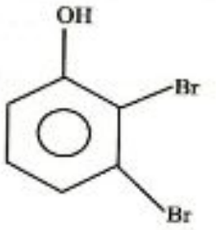
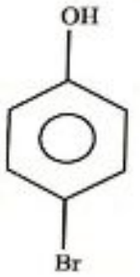
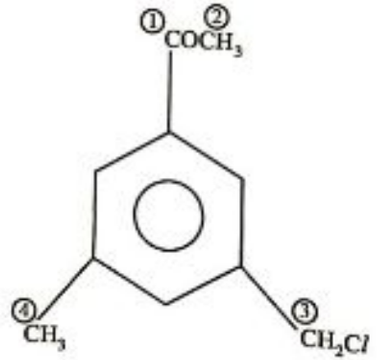


D



19 The structure of an organic compound X is shown. The side chain carbon atoms are numbered 1 to 4.



On which carbon atom(s), 1, 2, 3, and/or 4, does nucleophilic addition attack occur?

A 1 and 2
B 2 and 3
C 1 and 3
D 2 and 4

20 Ethanal may be converted to a three carbon acid in a two step process.

Which compound is the intermediate?

A CH_3COCN

B CH_3CH_2CN

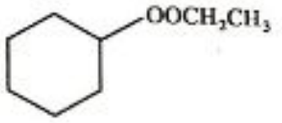
C $CH_3CH(OH)CN$

D $CH_2OHCH_2(OH)CN$

21 An organic compound, of molecular formula $C_6H_{12}O$, reacts as shown

$$C_6H_{12}O \xrightarrow[H^+]{Cr_2O_7^{2-}} N \xrightarrow[H^+]{C_2H_5OH} W$$

What is the formula of W?

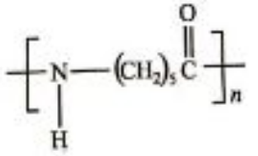
A 

B $CH_3(CH_2)_4CO_2CH_2CH_3$

C $CH_3CO_2H_2C(CH_2)_4CH_3$

D $CH_3(CH_2)_4COCH_2CH_3$

22 Nylon 6 has the formula shown and undergoes acid hydrolysis.



What is the product of the acid hydrolysis of nylon 6?

A $HO^-(CH_2)_5CO_2H$

B $HO-(CH_2)_5OH$

C $H_2N-(CH_2)_5CO_2H$

D $H_2N^-(CH_2)_5OH$

23 Which one is the strongest acid?

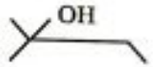
A chloroethanoic acid
B ethanoic acid
C ethylamine
D phenol

24 Which reaction does **not** produce benzoic acid?

A hydrolysis of $C_6H_5CO_2CH_2CH_3$
B hydrolysis of C_6H_5CN
C oxidation of $C_6H_5CH_3$
D oxidation of C_6H_5OH

25 Which alcohol undergoes iodoform reaction?

A 

B 

C 

D 

26 Which one is **not** a benefit of carrying out a reaction at nano scale?

A fewer reagents are used
B increased productivity
C increased by-product(s)
D increased rate of reaction

27 Which process minimises the formation of acid rain?

A emitting photochemical oxidants into the atmosphere
B cutting down trees
C reducing discharge of industrial waste
D using lean-burn engines

28 In steam distillation, the organic liquid vaporises at

A the boiling point of steam.
B a temperature equal to its boiling point.
C a temperature higher than its boiling point.
D a temperature lower than its boiling point.

29 Which reagent reduces vanadium ion from +5 to +4 only?

A SO_2
B Sn^{2+}
C Fe^{2+}
D Zn

30 Which statement correctly describes the properties of chromium and manganese?

A both Cr^{2+} and Mn^{3+} are oxidising agents.
B Cr^{2+} is an oxidising agent while Mn^{3+} is a reducing agent.
C Cr^{2+} and Mn^{3+} have the same electronic configuration.
D Only manganese has variable oxidation states.

Section B

For each of the questions in this section, one or more of the three numbered statements 1 to 3 may be correct.

Decide whether each of the statements is or is not correct. (You may find it helpful to put a tick against the statement(s) which you consider to be correct).

The responses A to D should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	*1 and 2 only are correct*	*2 and 3 only are correct*	*1 only is correct*

No other combination of statements is used as a correct response.

31 Which complex ion(s) is/are paramagnetic?

1. $[VF_6]^-$
2. $[V(C_2O_4)_3]^{3-}$
3. $[V(CN)_6]^{4-}$

32 Which statement(s) is/are true about $^{51}_{23}X^{3+}$, an ion of element X?

1. the electronic configuration of the ion is $1s^2 2s^2 2p^6 3s^2 3p^6$
2. X represents a transition metal
3. X forms ions of + 4 oxidation state

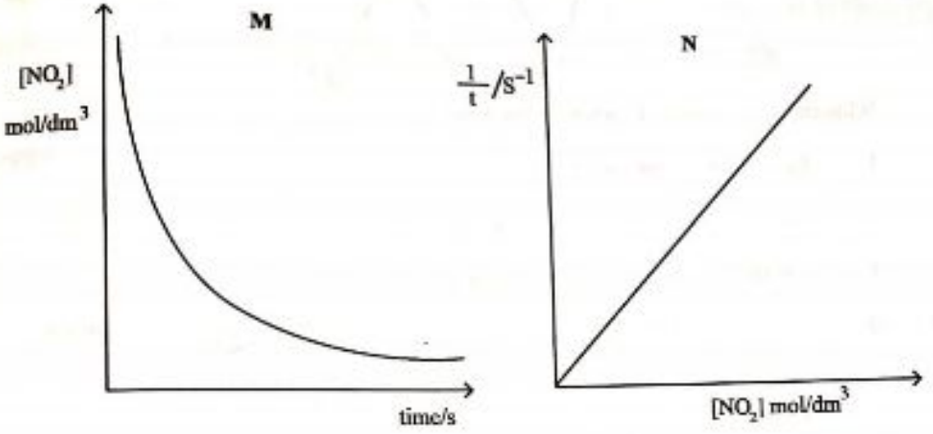
33 The effect(s) of a catalyst on a reversible reaction, is/are to

1. alter the mechanism of the reaction.
2. attain the equilibrium slowly.
3. attain a higher activation energy.

34 Nitrogen dioxide decomposes according to the equation.

$$NO_{2(g)} \rightarrow NO_{(g)} + \frac{1}{2}O_{2(g)}$$

Graphs **M** and **N** were obtained when the reaction kinetics were investigated.



Which statements is/are true about the kinetics of the reaction?

1. the reaction is zero order with respect to $[NO_2]$
2. the rate constant can be determined from graph **N**
3. the initial rate can be determined from graph **M**

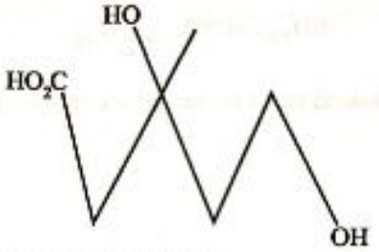
35 Chlorine reacts with cold dilute alkali to form

1. Cl^-.
2. ClO^-.
3. ClO_3^-.

36 Which statement(s) about magnesium sulphate is/are correct?

1. Its lattice energy is less than that of barium sulphate.
2. Its solubility in water is greater than that of barium sulphate.
3. It is added to acidic soils to neutralize excess acidity.

37 The structure of mevalonic acid is shown:



Which property is correct for mevalonic acid?

1. has only one chiral carbon atom
2. can be esterified both by ethanoic acid and ethanol in the presence of H^+ ions
3. contains both primary and secondary alcohol groups

38 During the formation of nylon-66 from hexane-1,6-dioic acid and hexane-1,6-diamine

1. amide linkages are formed
2. condensation polymerisation takes place
3. ammonia is eliminated

39 Which substance(s) evolve(s) ammonia gas when boiled with aqueous sodium hydroxide?

1. $CH_3CH_2NH_2$
2. CH_3CONH_2
3. $CH_3CONH_3^+$

40 Which statement(s) is/are true about gas liquid chromatograph (GLC) and high performance liquid chromatography (HPLC)?

1. GLC uses a longer column than HPLC.
2. In both GLC and HPLC, the stationery phase is a liquid.
3. In both GLC and HPLC, the mobile phase is a liquid.

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General Certificate of Education Ordinary Level

CHEMISTRY PAPER 1 6031/1

JUNE 2019 SUGGESTED ANSWERS AND SOLUTIONS

Question number	key	Comment
1	C	chlorine reacts disproportionately with NaOH hence need to separate with a membrane
2	B	oxidation state of Br in $Br^- = 1$, in BrO_3^- $OX(Br) + 3(-2) = -1, OX(Br) = +5$
3	B	ΔH_f^θ when one mole of a compound is formed from its elements under standard conditions
4	B	
5	A	
6	B	$\frac{rate_1}{rate_2} = \frac{k[y]^n}{k[y]^n}$ for y: $\frac{2}{8} = \left[\frac{1}{2}\right]^n$; n = 2 for x: $\left[\frac{1}{2}\right] = \left[\frac{36}{72}\right]^m$; m = 1 rate = $K[X][Y]^2$
7	B	
8	D	use the equations $2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^2 + 2I^-$ $2Cu^{2+}4I^- \rightarrow 2CuI + I_2$
9	A	
10	D	
11	A	
12	D	
13	B	resulting solution should produce an alkaline solution – high pH
14	A	
15	D	the smaller the charge density the less polarising effect of the anion the greater is the thermal stability of the nitrate
16	C	

17	D	
18	A	
19	C	carbon attached to electro negative atom will have its electron pulled away resulting in partial positive charge and easy target by nucleophiles.
20	C	
21	B	
22	C	Nylon 6 is made from single monomer with 6 carbons consisting of amine and carboxyl group.
23	A	
24	D	$-OH$ group of phenol cannot be oxidised phenol is a weak acid
25	A	
26	C	
27	D	
28	D	
29	C	Use reduction potential $VO_3^- + 2H^+ + 2e^- \Rightarrow +VO^+ + H_2O \quad \epsilon^\theta = +1.00v$ $Fe^{3+}/Fe^{2+} = +0.77\text{v}$; $Zn^{2+}/Zn = -0{,}76$ v; $SO_4^{2-}/SO_2 - 0.17\text{v}$; $Sn^{4+}/Sn^{2+} = 0.15\text{v}$; $\epsilon^\theta_{cell} = \epsilon^\theta_{reduced} - \epsilon^\theta_{oxidised}$; Fe^{2+} is preferred has a more positive ϵ^θ value
30	C	
31	C	Paramagnetic compound have electrons with single spins.
32	C	
33	C	
34	C	
35	B	
36	B	
37	B	has one chiral carbon and can be esterified by both ethanoic acid and ethanol, contains a tertiary and primary – OH groups
38	B	

39	C	$CH_3CH_2NH_2$ is a base can not react with $NaOH$; amides (2 *and* 3) react
40	B	mobile phase is a gas GLC, its stationary phase is a liquid

Answer all questions

1 **(a)** Define the term

(i) *metallic bond,*

(ii) *atomic number.*

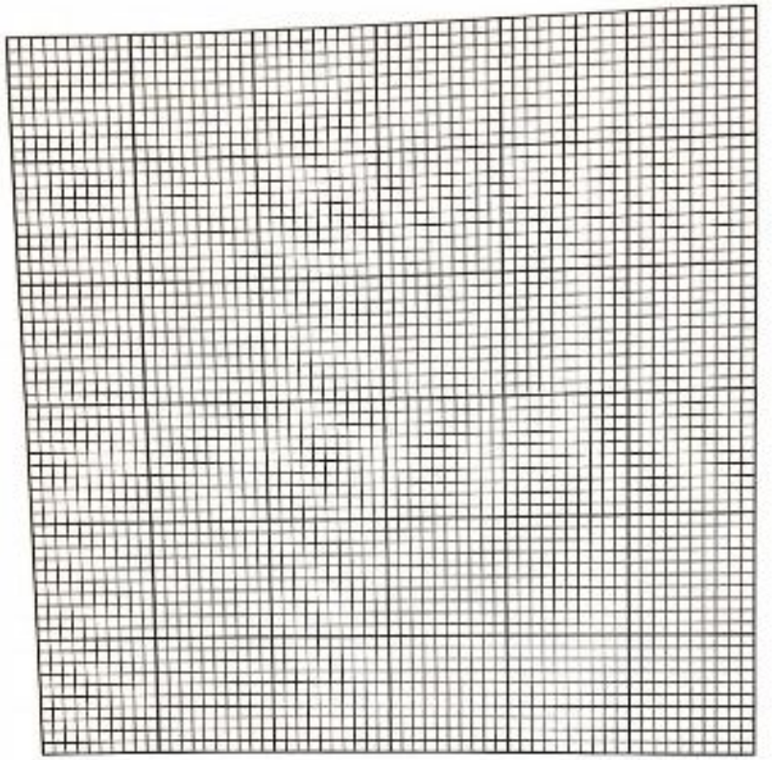
[2]

(b) **Table 1.1** shows percentage (%) relative abundances and m/e values for strontium.

Table 1.1

% relative abundance	m/e
10	86
7	87
83	88

(i) Draw the mass spectrum of strontium.



(ii) Calculate the relative atomic mass of strontium.

[4]

(c) Show how the molecule H_2NCH_2COOH forms hydrogen bonds.

[2]

(d) Explain why graphite is used as a lubricant.

[2]

[Total 10]

2 (a) (i) Define the term *standard enthalpy change of atomisation.*

_____

_____

_____

(ii) Write an equation for the atomisation of ethanol.

_____

(iii) Determine the standard enthalpy change of atomisation of ethanol.
[Use of relevant data from the data booklet is recommended]

[4]

(b) (i) Carbon reacts with hydrogen and oxygen according to the equation

$$2C_{(s)} + 3H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow C_2H_5OH_{(l)}$$

Name the enthalpy change represented by the chemical change.

_____

(ii) **Table 1.2** shows the enthalpy changes of combustion for the product and reactants in the reaction in **b(i)**.

Table 1.2

substance	$\Delta H_c^{\theta}\ (kJmol^{-1})$
CH_3CH_2OH	− 1 367
H_2	− 286
C (graphite)	− 1 393

Calculate ΔH_r^{θ} for the chemical change in **b(i)**.

Draw an energy reaction pathway diagram for the reaction in **b (i)**.

[6]
[Total:10]

3 (a) State and explain the physical states, at s.t.p, of

(i) CO_2,

_____

_____

(ii) PbO.

_____

_____

[4]

(b) (i) Write a balanced chemical equation to show how germanium reacts with chlorine.

_____

_____

(ii) Describe the structure and type of bonding in the germanium compound produced in **b (i)**.

_____

_____

(iii) Comment on the boiling point of the germanium compound produced in **b(i)**.

_____

_____

_____

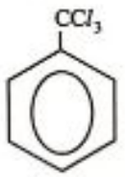
[4]

(c) Describe and explain the variation in electrical conductivities of Group (II) elements.

[2]
[Total 10]

4 (a) **Table 4.1** shows incomplete information about some reactions of methylbenzene with excess chlorine.

Table 4.1

condition(s) for reaction	type of reaction	structural formula of organic product
	electrophillic substitution	
		

(i) Complete **Table 4.1** to determine how methylbenzene reacts with **excess** chlorine under different conditions.

(ii) Give the mechanism for the electrophilic substitution reaction.

[7]

(b) Explain why

(i) a solution of hydrogen chloride in methylbenzene is **not** acidic.

(ii) methylbenzene is insoluble in water.

[3]
[Total:10]

5 (a) **Fig. 5.1** shows the structure of a flavonol, a natural organic molecule.

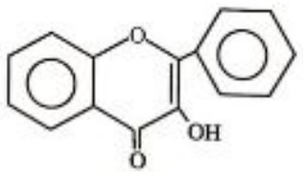


Fig. 5.1

(i) State any **three** functional groups in the flavonol.

1.

2.

3.

(ii) Describe observations made when the flavonol reacts with

1. 2,4-dinitrophenylhydrazine,

_____

2. aqueous bromine.

_____ [5]

(b) Draw the structure of the organic products formed when the flavonol reacts with

(i) ethanoic acid under reflux,

(ii) $LiAlH_4$. [2]

(c) **Fig. 5.2** shows the structure of aspartic acid.

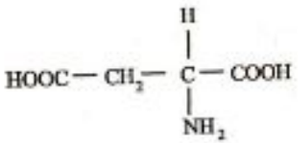


Fig. 5.2

Draw the structure of the predominant ion formed when aspartic acid is in

1. a neutral solution,

2. an alkaline solution,

3. an aqueous solution of HCl .

[3]
[Total 10]

6 (a) (i) Define the term *heterogeneous catalysis*.

_____

_____

(ii) Explain why transition metals are used in hydrogenation reactions.

_____

_____ [3]

(b) Draw diagrams to show the structures of *cis* and *trans* tetraaminedichlorochromium (III) ions.

[2]

(c) (i) Define the term *nanotechnology*.

_____

_____

(ii) State any **three** biomedical applications of nanotechnology.

1. _____

2. _____

3. _____ [5]

[Total:10]

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SUGGESTED ANSWERS AND SOLUTIONS

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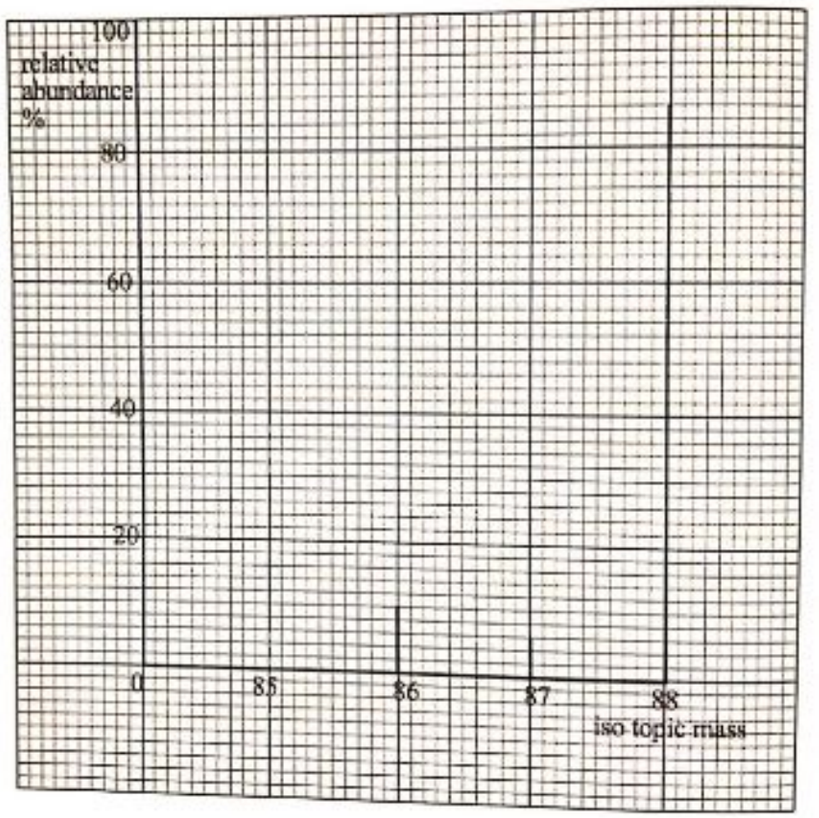
CHEMISTRY **6031/2**

(a) (i) – strong electrostatic attraction between a lattice of positive ions and a sea of delocalized electrons/AW

(ii) – number of protons in the nucleus of the atom; / number of electrons in an atom

(b) (i)

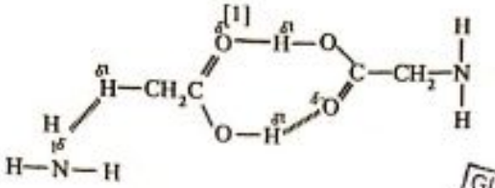


(ii) $= \left(\frac{86 \times 10}{100}\right) + \left(\frac{87 \times 7}{100}\right) + \left(\frac{88 \times 83}{100}\right)$

$= 8.6 + 6.09 + 73.04$

$= 87.73$

(c) - Show at least 2 different (O-H, N-H) with any molecule or with its itself.
Show at least one pair of partial charges



(d) graphite is slippery due to layers that can slide over each other;
weak Van der Waals forces between layers;

2 (a) (i) the heat change when when a substance produces one mole of gaseous atoms under standard conditions.

(ii) $CH_3CH_2OH_{(l)} \longrightarrow 2\,C_{(g)} + 6H_{(g)} + O_{(g)}$

(iii) ΔH atm $= 5 \times 410 + 350 + 460 + 360$

$= +3\,220\ kJmol^{-1}$

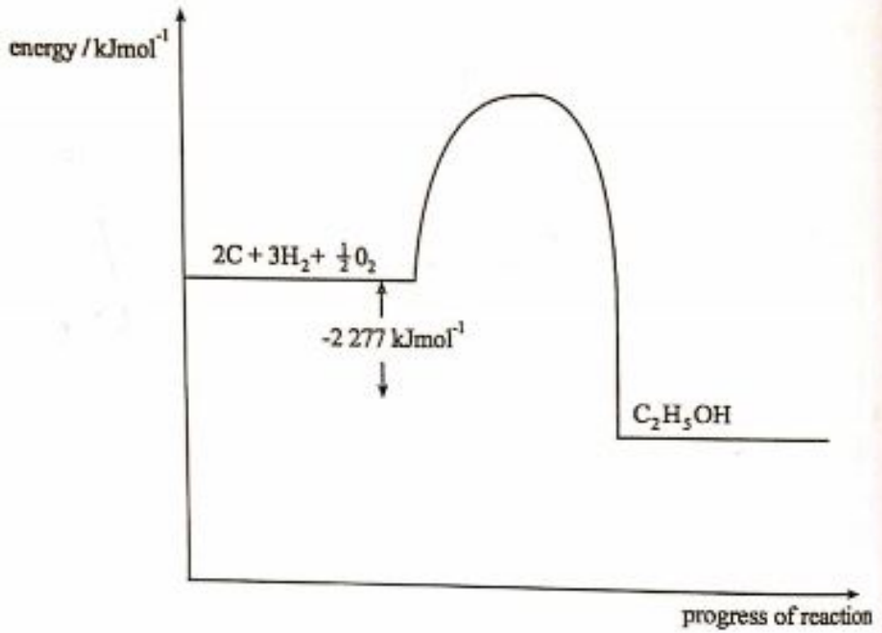
(b) (i) Standard enthalpy change of formation

(ii) $\Delta H_r^{\theta} = 2\,(-1\,393) + 3\,(-286) + 1\,367$

$= -1\,644 + 1\,367$

$= -2\,277\ kJmol^{-1}$

(iii)



3 (a) CO_2 - gas

- Simple molecular structure

PbO - Solid

- giant ionic structure

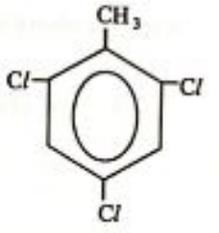
(b) (i) $Ge + 2Cl_2 \longrightarrow GeCl_4$;

(ii) Simple molecular covalent bond;

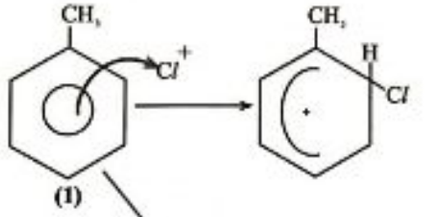
(iii) low boiling point;
simple molecule;
with weak van der waals forces

(c) decreases down the group;
electron charge density decrease down the group

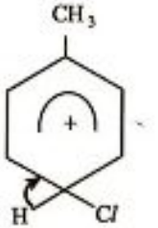
4 (a)

conditions required for reaction	type of reaction	organic Product (s)
(i) Fe/ $FeCl_3$ / $AlCl_3$ / Halogen carrier [1]		 [1]
UV light [1]	Free radial; Substitution; [1]	

(ii) $Cl - Cl + FeCl_3 \rightleftharpoons Cl^+ + FeCl_4^-$



(1)



(1)

(b) (i) HCl does not dissociate;
to form H_{aq}^+ ions which make the solution acidic;

(ii) Methylbenzene has Vander Waals forces where water has hydrogen bond so methylbenzene cannot dissolve in water /
Different intermolecular forces /

No chemical reaction

5 (a) (i) ketone reject carbonyl

hydroxyl,

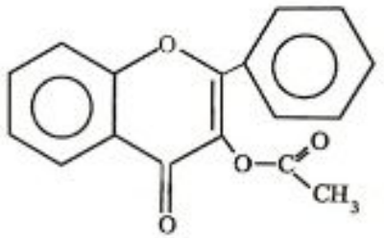
alkene, / carbon double bond carbon

aryl / benzene / phenyl / ether, ethoxy

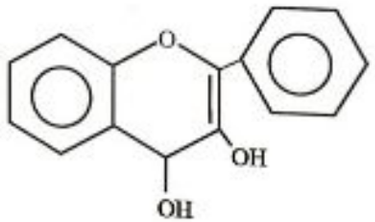
(ii) 1. Orange / yellow crystals/ ppt
yellow crystals

2. aqueous bromine is decolorised / discharged

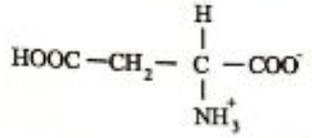
(b) (i)



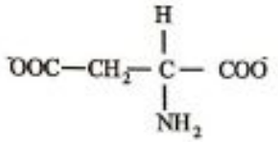
(ii)



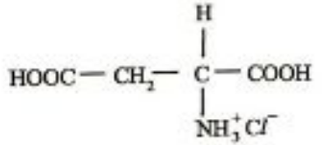
(b) (i) 1. Zwitterion;



2. negatively charged ion



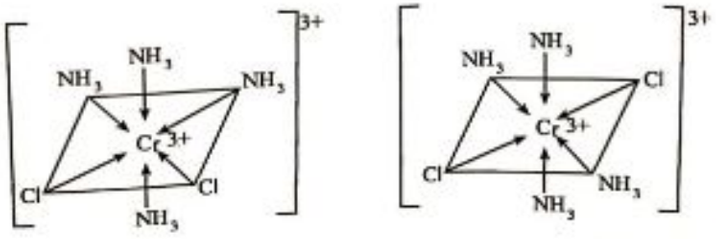
3. +ve ion



6 (a) (i) Heterogeneous catalysis is a reaction in which the reactants are in different phase with the catalyst;

(ii) They have partially filled 'd'-orbitals;
Catalyst / speed up / they catalyse

(b)



(c) is science which deals with particles; of range 1nm – 100nm;

(d) Bioimaging of tissues;
Drug carrier molecules;
Regenerative medicine;
Drug toxicity reduction;

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL
General Certificate of Education Advanced Level

CHEMISTRY 6031/3
PAPER 3

JUNE 2019 SESSION 2 hours 30 minutes

Additional materials:
- Answer paper
- Data Booklet
- Mathematical tables and/or electronic calculator

TIME: 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **six** questions.

Answer **two** questions from Section A, **one** question from Section B, **two** questions from Section C and **one** question from section D.

Write your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for good English and clear presentation in your answers.

Section A

Answer any two questions from this section.

1 (a) (i) State and explain the trend in the 1st ionisation energies of elements in the same group.

(ii) Successive ionisation energies of three elements, **A**, **B** and **C**, are given in **Table 1.1**.

Table 1.1

element	ionisation energies/kJmol^{-1}			
	1st	2nd	3rd	4th
A	494	4 560	6 940	9 540
B	418	3 070	4 600	5 860
C	403	2 633	3 860	5 080

State and explain the Group of the Periodic Table to which the three elements are most likely to belong.

[4]

(b) (i) Explain why the first ionisation energy of Boron is lower than that of Berylium.

(ii) Write an equation that represents the second ionisation energy of Boron.

[3]

(c) (i) Draw an energy level diagram to show the electronic configuration of Boron.

(ii) Describe the shapes of the s and the p orbitals.

[3]

(d) The solubility product of iron (II) hydroxide is x mol^{3}dm^{-9}.

(i) Calculate the solubility of iron (II) hydroxide in terms of x.

(ii) Describe and explain the effect on the value in (i) of

1. increasing the temperature,

2. dissolving the iron (II) hydroxide in $NaOH_{(aq)}$.

[5]
[Total: 15]

2 (a) A hydrogen-oxygen fuel cell is shown in **Fig. 2.1.**

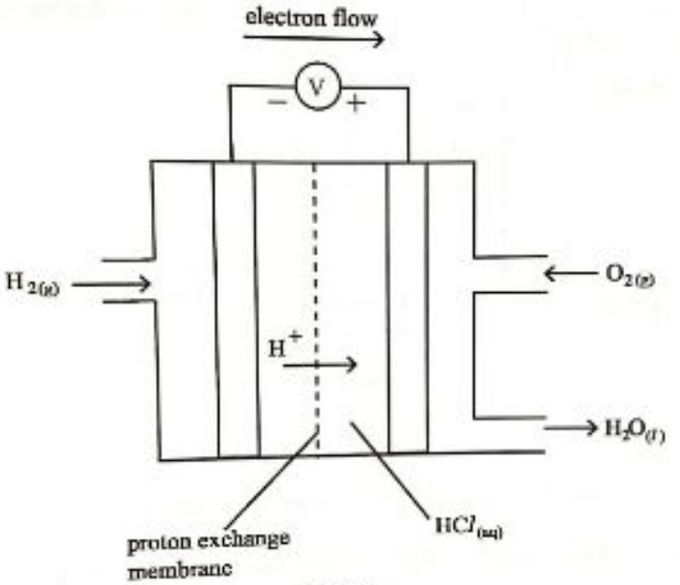


Fig. 2.1

(i) Write the equation for the overall cell reaction occurring in the hydrogen-oxygen fuel cell.

(ii) Calculate E^θ of the fuel cell. [3]

(b) State any **two**

(i) advantages of using fuel cells compared to fossil fuels,

(ii) limitations to the use of fuel cells. [3]

(c) An electrolytic cell was set up to determine the value of the Avogadro constant as shown in **Fig. 2.2**. 1.90 A of current were passed through the aqueous copper (II) sulphate for 50 minutes.

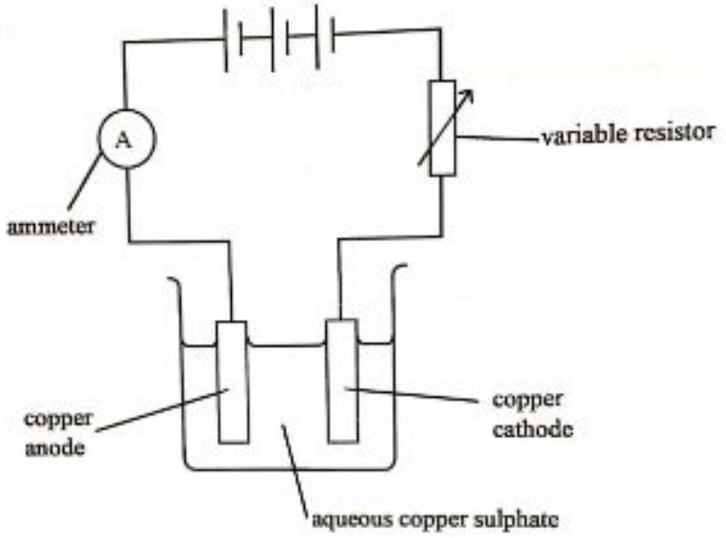


Fig. 2.2

(i) State any **three** observable changes that occurred.

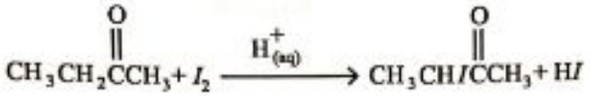
(ii) The mass of the cathode changed from 70.14 g to 71.97 g.

Calculate the Avogadro constant.

(iii) Explain why measuring the decrease in mass of the anode would be preferred to measuring the increase in mass of the cathode.

[9]
[Total 15]

3 **(a)** Butanone reacts with iodine in an acid catalysed reaction as shown.



(i) Describe how the rate of this reaction can be determined.

(ii) An experimental investigation showed that the reaction is zero order with respect to iodine and that butanone exists in two interconvertible forms shown, in **Fig. 3.1**.

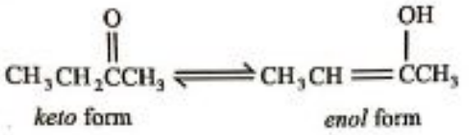


Fig. 3.1

Propose a **two** step mechanism for the reaction.

[6]

(b) **(i)** Sketch graphs, on the same axes, to show how the rate of a reaction varies with concentration of a reactant for a

1. zero order,
2. first order and
3. second order reaction.

(ii) The overall order of a reaction was found to be third order.

Deduce the units of the rate constant for the reaction.

[4]

(c) Explain the following observations.

(i) Some collisions of particles do not lead to chemical reactions.

(ii) An increase in temperature increases the rate of a reaction.

[5]

[Total:15]

Section B

Answer any one question from this section.

4 **(a)** **Table 4.1** shows the boiling points of some of the Group (IV) tetrachlorides.

Table 4.1

tetrachloride	boiling point/°C
$SiCl_4$	58
$GeCl_4$	87
$SnCl_4$	114

(i) State the shape of the tetrachlorides formed by Group (IV) elements.

(ii) Explain the variation in the boiling points of the chlorides in **Table 4.1**.

(iii) Explain why CCl_4 does **not** hydrolyse.

(iv) Write an equation for the reaction between $SiCl_4$ and water.

[5]

(b) Write balanced chemical equations for the following reactions:

(i) CO and Fe_2O_3

(ii) SnO_2 and concentrated HCl

(iii) PbO_2 and concentrated HCl

[6]

(c) State and explain the acid-base nature of

(i) CO,

(ii) GeO_2.

[4]
[Total 15]

5 (a) **Table 5.1** shows the melting points of the chlorides of the elements sodium to phosphorus.

Table 5.1

compound	melting point /°C
sodium chloride	808
magnesium chloride	714
aluminium chloride	sublimes at 178°C
silicon tetrachloride	−70
phosphorus (v) chloride	162

(i) Explain the variation in the melting points of the chlorides.

(ii) Write balanced chemical equations for the reaction of each of the following chlorides with water:

1. sodium chloride
2. aluminium chloride
2. phosphorus (V) chloride

[7]

(b) A 6.6125 g sample of a nitrate of a Group (II) metal, **M**, decomposed on heating to liberate 1 875 cm^3 of gas at room temperature and pressure.

(i) Write an equation for the decomposition of the nitrate.

(ii) Deduce, with reasons, the identity of **M**.

[5]

(c) (i) Describe **two** observations that occur when sodium reacts with chlorine.

(ii) Explain why sodium chloride is used as a food preservative.

[3]

[Total:15]

Section C

Answer any two questions from this section

6 **Fig. 6.1** shows how an organic compound can be converted to compounds **G**, **H** and **I**.

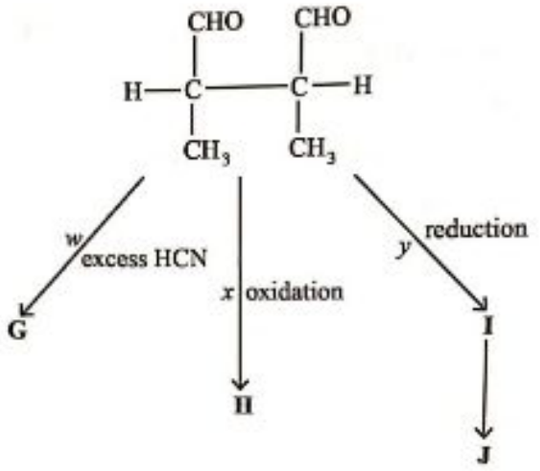


Fig. 6.1

(a) **(i)** State, with reasons, the condition(s) for reaction *w*.

(ii) Name reaction *w*.

(iii) Describe the mechanism for reaction *w*.

[6]

(b) **(i)** State the reagents and conditions for

1. reaction *x*,
2. reaction *y*.

(ii) Draw the structures of **H** and **I**.

(iii) Name compounds **H** and **I**.

(iv) Products **H** and **I** can react to form compound **J**.

Name the type of reaction.

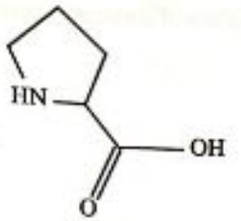
[7]

(c) Describe a one-step laboratory test to distinguish between compounds **H** and **I**.

[2]

[Total 15]

7 (a) **Fig. 7.1** shows the structure of an amino acid, proline.



proline

Fig. 7.1

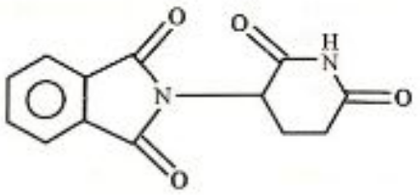
(i) Explain why proline has a high melting point of 223 °C.

(ii) Draw the structure of proline in a neutral solution.

(iii) Write equations to show the buffering action of proline.

[5]

(b) **Fig. 7.2** shows the structure of thalidomide, a sedative drug.



thalidomide

Fig. 7.2

(i) Draw the structure of the product formed when thalidomide reacts with

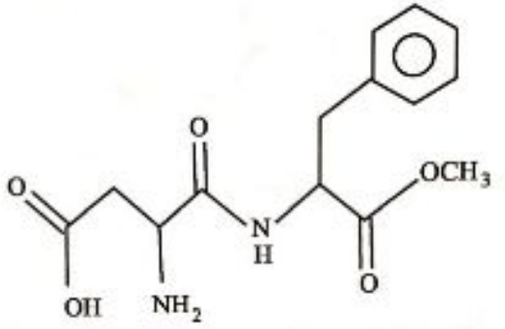
1. $Br_{2(aq)}$,
2. acidic solution.

(ii) Explain why thalidomide exists in two different forms.

(iii) Suggest how an unknown sample of thalidomide can be identified using solubility tests.

[10]
[Total: 15]

8 (a) **Fig. 8.1** shows the structure of aspartame, a methyl ester of the dipeptide of two amino acids.



aspartame

Fig. 8.1

(i) Write the structures of any **two** functional groups present in aspartame.

(ii) Comment on the solubility of aspartame in water.

(iii) Draw the structural formulae of the products for the complete hydrolysis of aspartame in aqueous HCl.

(iv) Name the **two** amino acids from which aspartame is made.

[8]

(b) Compare the basic strengths of NH_3, $CH_3CH_2NH_2$ and $C_6H_5NH_2$. [3]

(c) The disposal of condensation polymers in landfill sites is more environmentally acceptable than the disposal of addition polymers.

(i) Distinguish between a condensation polymer and an addition polymer.

(ii) Explain why the disposal of condensation polymers in landfill sites is more acceptable.

[4]
[Total: 15]

Section D

*Answer any **one** question from this section*

9 (a) Explain why

(i) blocks of magnesium are attached to underground iron water pipes,

(ii) galvanised corrugated iron roofing sheets do not rust even if the zinc coating is scratched,

(iii) tin food cans quickly rust when the tin coating gets scratched. [6]

(b) During preparation, phenylamine, is isolated from the mixture by steam distillation.

(i) Describe how the steam distillation is carried out.

(ii) Explain why simple distillation is **not** an appropriate method of isolating the components.

[6]

(c) **Fig. 9.1** shows ligand substitution reactions that occur with $Cu^{2+}_{(aq)}$.

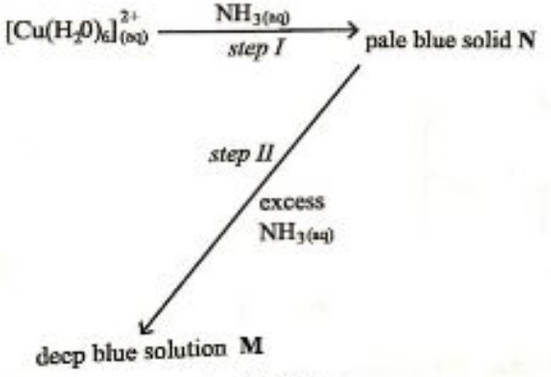


Fig. 9.1

(i) State the colour of $[Cu(H_2O)_6]^{2+}$ aqueous solution.

(ii) Write the formula of

1. solid **N**,

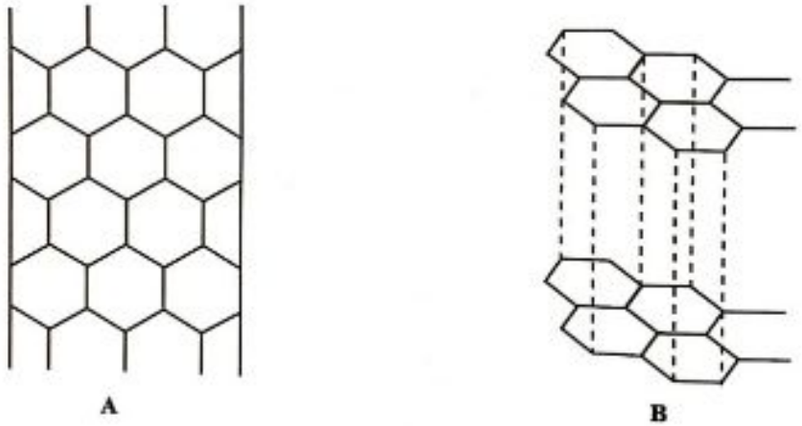
2. solution **M**. [3]

[Total: 15]

10 (a) Outline any **two** advantages of sorting waste material before disposal. [2]

(b) State any **three** problems associated with land filling. [3]

(c) **Fig. 10.1** shows the structures of two allotropes of carbon, **A** and **B**. The c-c bond length in **A** is about 0.142 nm.



A **B**

Fig. 10.1

(i) Explain why allotrope **A** is classified as a nano material.

(ii) Name the carbon allotropes **A** and **B**. [5]

(d) Comment on the potential hazards of using nano materials. [5]

[Total: 15]

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED SOLUTIONS

JUNE 2019

CHEMISTRY **6031/3**

1 (a) (i) decrease down the group;
because distance from nucleus to outer electrons increases / increased shielding of outer electrons by inner electrons;

(ii) group I;

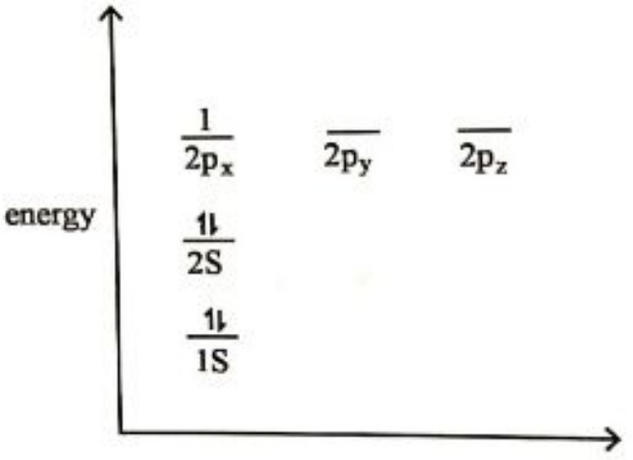
largest difference between the first and second ionisation energies;
compare all IEs not just first and second IE

(b) (i) In Berylium the outermost electron is removed from 2s while in Boron the electron is removed from 2p;

2p electron is at higher energy level

(ii) $B^{+}_{(g)} \longrightarrow B^{2+}_{(g)} + e^{-}$ *[state symbols)are important and should be included]*

(c) (i)



(ii)

S - orbital — spherical

p - orbital — dumb bell shaped

(d) (i) $Fe(OH)_2 \rightleftharpoons Fe^{2+} + 2OH^{-}$;

$Ks_p = [Fe^{2+}][OH^{-}]^2$;

$x\ mol^3 dm^{-9} = [Fe^{2+}][2Fe^{2+}]^2 / 4y^3$

$solubility = \left(\frac{x}{4}\right)^{\frac{1}{3}}$

$[Fe^{2+}] = \left(\frac{x}{4}\right)^{\frac{1}{3}}\ mol\ dm^{-3}$

(ii) 1. Solubility increases;

$Fe(OH)_{2(s)} \rightleftharpoons Fe^{2+}_{(aq)} + 2OH^{-}_{(aq)}$

∴ increase in temperature shifts the equilibrium to the right;

2. Solubility decreases; due to common ion effect

Common ion effect/ $Fe(OH)_{2(s)} \rightleftharpoons Fe^{2+}_{(aq)} + 2OH^{-}_{(aq)}$

When concentration of OH^- ions increases, equilibrium shifts to the left;

2 (a) (i) $\begin{pmatrix} O_2 + 4H^+ + 4e^- \rightleftharpoons 2H_2O + 1{,}23V \\ 2H^+ + 2e \rightleftharpoons H_2 \quad 0{,}00\ V \end{pmatrix}$

Overall: $O_2 + 2H_2 \longrightarrow 2H_2O$;

(ii) $E^\theta = E^\theta$ reduction $- E^\theta$ oxidation

$= +1{,}23 - 0{,}00$

$= +1{,}23$ V; *avoid omitting (+) sign*

(b) 1. - less pollution/no carbon dioxide produced/water is the only product
- more efficient
- less dependence on fossil fuels which are non-renewable

[2]

2. - high cost of manufacturing
- take up more space
- hydrogen is difficult to store/transport

(c) (i) - change in size of electrodes; anode becomes smaller cathode gets bigger;
- sludge at bottom of beaker;
- change in colour of electrolyte;

the colour does not change because copper ions consumed are replaced on the opposite electrode

(ii) Q = It

= 1,90 × 50 × 60

= 5 700 C ;

m(Cu) deposited = 71,97 – 70,14

= 1,83 g;

1.83 g Cu → 5 400 c

63.5 g (1 mole) → ? more

$\frac{63.5}{1.83} \times 5\,700 = 197\,786$ C

$Cu^{2+} + 2e^{-} \longrightarrow Cu$

$\frac{1}{2} \times 197\,786 = 98\,893$ C;

L = F/e

F – Faraday's constant
e – charge of an electron

$= \frac{98\,893}{1{,}6 \times 10^{-19}}$

$= 6.18 \times 10^{23}$;

/ Moles of Cu produced $= \frac{m}{M} = \frac{1{,}83}{63.5}$

$=$ 0,0288 mol;

$Cu^{2+} + 2e^{-} \longrightarrow Cu$

Moles of electrons needed $= \frac{2}{1}$n(Cu)

$= \frac{2}{1}(0{,}0288)$

$=$ 0,0576

Q = It = 1,9 × 50 × 60 = 5 700 C;

Number of electrons passed $= \frac{5\,700}{1{,}6 \times 10^{-19}}$

$= 3.5625 \times 10^{22}$;

$L = \frac{F}{e} = \frac{3.5625 \times 10^{22}}{0{,}0576}$

$= 6.18 \times 10^{23}$;

(iii) The copper may not stick to the cathode very well/some of the formed

copper may fall into the electrolyte; so the recorded mass of the cathode will be less than the actual;

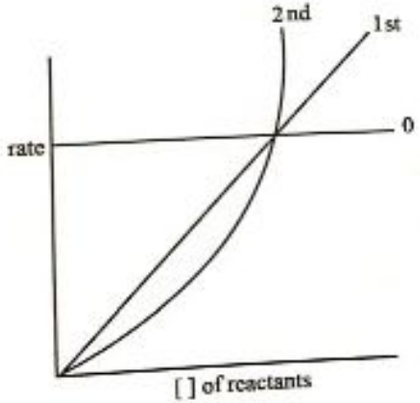
3 (a) (i) titrimetric analysis
- Mix known amounts of reactants and simultaneously start a stop watch;
- periodically sample and quench reaction mixture (by adding an alkali to remove the catalyst);
- titrate the sample with a thiosulphate solution of a known concentration;
- plot a graph of volume of thiosulphate against time (and use it to deduce order of reaction);

(A) Correct description of colorimetry;
- Mix known amounts of reactants and start stop watch
- place in a colorimeter and measure colour intensity with time
- plot a graph of colour intensity with time

(ii) $CH_3CH_2COCH_3 + H^+ \longrightarrow CH_3CH = COHCH_3$ (slow)

$CH_3CH{=}C(OH)CH_3 + I_2 \longrightarrow CH_3CHICOCH_3 + HI$

(b) (i)

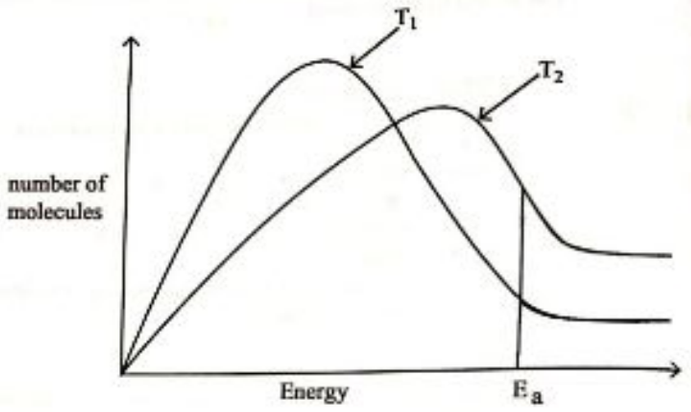


(ii) $\text{mol dm}^{-3}\text{s}^{-1} = K(\text{mol dm}^{-3})^3$

$K = \frac{s^{-1}}{(\text{mol dm}^{-3})^3} = \text{mol}^{-2}\text{dm}^6\text{s}^{-1}$;

(c) (i)
- Very few particles will be having $E \geq Ea$;
- particles not in correct orientation when they collide;

(ii)



☐ fraction of molecules with $E \geq E_a$ at lower temperature T_1

☐ fraction of molecules with $E \geq E_a$ at higher temperature T_2

- increasing temperature increases average kinetic energy of the molecules
- more molecules have energy ≥ Ea;
- ∴ More frequent effective collisions

4 (a) (i) Tetrahedral shape;

(ii) Number of electrons per molecule increases down the group/molecules become bigger down the group;

Van der Waals intermolecular forces become stronger;

(iii) C in CCl_4 does not have low-lying d orbitals;

(iv) $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$ / $SiCl_4 + 4H_2O \rightarrow Si(OH)_4 + 4HCl$/ $SiCl_4 + 4H_2O \rightarrow SiO_2.2H_2O + 4HCl$;

(b) (i) $3CO_{(g)} + Fe_2O_{3(s)} \longrightarrow 2Fe_{(s)} + 3CO_{2(g)}$;

(ii) $S_nO_{2(s)} + 4HCl_{(l)} \longrightarrow S_nCl_{4(aq)} + 2H_2O_{(l)}$;

(iii) $PbO_{2(s)} + 4HCl_l \longrightarrow PbCl_{2(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$;

(1 mark for correct product, 1 mark for balanced equation) (ignore state symbols)

(c) (i) CO is neutral;

(ii) GeO_2 is amphoteric;

$GeO_2 + 4HCl \longrightarrow GeCl_4 + 2H_2O$;

$GeO_2 + 2NaOH + 2H_2O \longrightarrow Na_2[Ge(OH)6]$;/

Or ionic

$GeO_2 + 4H^+ \longrightarrow Ge^{4+} + 2H_2O$;

$GeO_2 + 2OH^- \longrightarrow GeO_3^{2-} + H_2O$/

$GeO_2 + 2OH^- + 2H_2O \longrightarrow [Ge(OH)6\ ]^{2-}$;

5 (a) (i) $NaCl$ and $MgCl_2$ are giant ionic;

They have high melting points due to presence of strong ionic bonds which require more energy to be broken.

Increase in covalency in $MgCl_2$ due to higher charge density on Mg^{2+} makes it lower melting than $NaCl$;

$AlCl_3$, $SiCl_4$, PCl_5 are simple molecular with weak van der Waals forces of attraction between the molecules hence low melting points.

Comment: size of vanderwaals of simple molecule is not dependent on mass but rather on number of electrons or molecular size.

Strength of van der Waals forces increase with increase in the number of electrons per molecule thus melting points increase in the order $AlCl_3 > PCl_5 > SiCl_4$,

(ii) 1. $NaCl + aq \longrightarrow Na^+(aq) + Cl^-(aq) pH = 7$;

2. $AlCl_3 + 6H_2O \longrightarrow [Al(H_2O)_5OH]^{2+} + H^+ + 3Cl^-$;

3. $PCl_5 + 4H_2O \longrightarrow H_3PO_4 + 5HCl$

(b) (i) $M(NO_3)_2 \longrightarrow MO + 2NO_2 + \frac{1}{2}O_2$;

(ii) n(gas) = $\frac{1\,875}{24\,000} = 0{,}78125$ mol;

n (nitrate) = $\frac{1}{2{,}5} \times 0{,}078125$

= 0,03125 mol

Mr = $\frac{m}{n} = \frac{6,6125}{0,03125} = 211,6$;

Ar (M) = 211,6 – 2 (14 + 48)

= 87,6

∴ M is strontium

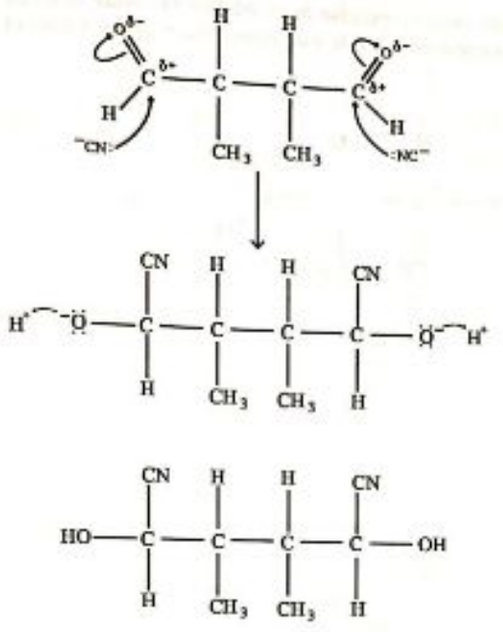
(c) (i) burns with a yellow flame;
white crystalline solid formed;

(ii) dehydrates; decomposes; prevents growth of microorganisms;

6 (a) (i) Traces of NaCN/KCN;
to provide the CN^- (speed initiate) up the reaction;
/since HCN is a weak acid / Adding an alkali NaOH/KOH to increase concentration of CN^-; since HCN is a weak acid with low concentration of CN^-;/$HCN + OH^- \longrightarrow CN^- + H_2O$;

(ii) Nucleophillic addition;

(iii)



(b) (i) 1. Heat/reflux with $K_2Cr_2O_7$ in H_2SO_4;

2. $NaBH_4$ / LiA*l*H_4/H_2+N*i* catalyst or Pt catalyst;

(ii) H – $HO_2CCH(CH_3)CH(CH_3)CO_2H$;

I – $CH_2(OH)CH(CH_3)CH(CH_3)CH_2OH$;

(iii) H – 2,3 – dimethyl – 1, 4-butanedioic acid;
I – 2,3 – dimethylbutan – 1, 4 – diol;

(iv) Esterification / condensation;

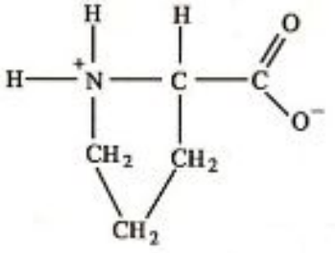
(c) Add Na_2CO_3/$NaHCO_3$ to both H and I;

It produces bubbles of gas, CO_2, but not with I;

/Heat with acidified $K_2Cr_2O_7$, I turns colour of $K_2Cr_2O_7$ from orange to /green, no observable change with H;
/Heat with cone H_2SO_4 and ethanoic acid;
Pleasant smell with I. No reaction with H;

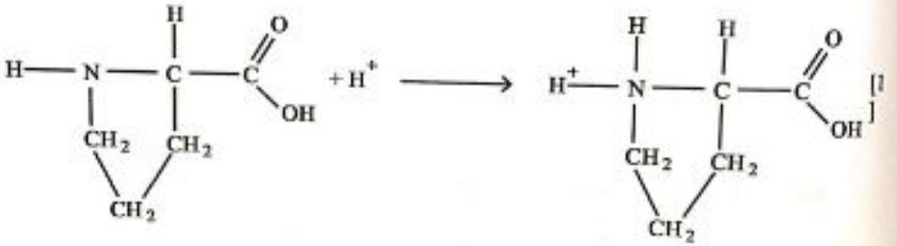
7 (a) (i) Amino acids crystalise from solution in Zwitterionic form hence are ionic solids with strong electrostatic forces of attraction;

(ii)

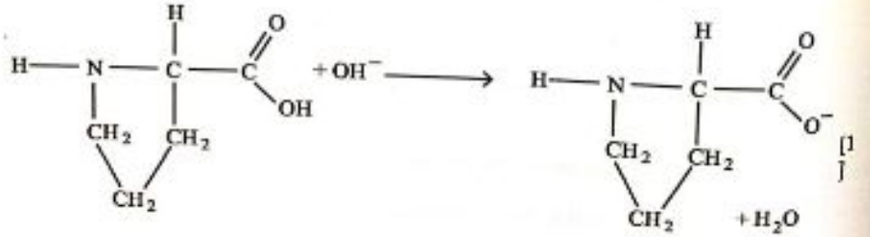


[1]

(iii)



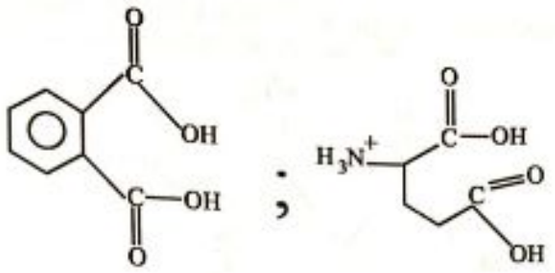
[1]



[1]

(b) (i) 1. Bromine on any position of benzene ring;

2. the amine salt;



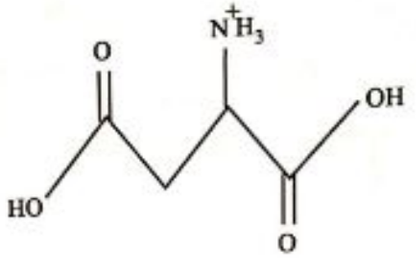
(ii) optical isomers;
has one chiral center;
forms enantiomers/mirror images;

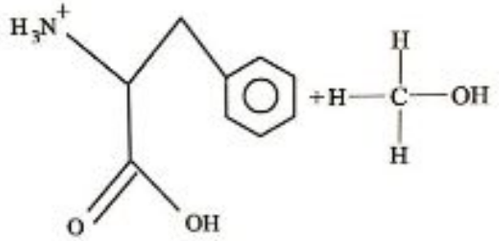
(iii) add sample to water / acid / base;
stir gently;
heat;
hydrolysis; dissolves;

8 (a) (i)
- NH_2 (amine)
- COOH (carboxylic acid)
- -COO- (ester)
- -CONH (amide)
- C_6H_5- Phenyl

(ii) Soluble in water;
forms hydrogen bonds with water

(iii)





(iv) 2-aminobutanedioic acid/aspartic acid;

2-amino-3-phenylpropanoic acid/phenylalanine;

(b) $CH_3CH_2NH_2 > NH_3 > C_6H_5NH_2$

- Lone pair of electrons on N in phenylamine partially delocalised into the benzene ring;
- positive inductive effect of $-CH_3CH_2$ group increases electron density on N;
- H atoms on NH_3 have no effect on lone pair of electrons on the nitrogen atom

(c) (i) Addition polymer formed by reacting two or more monomers with no resulting water or other by product/AW;

Addition	Condesation
- monomers react to form a single product;	- monomers react to produce two products (a polymer and a small molecule e.g. H_2O / HCl)

*[Two monomers **do not** make a polymer.]*

(ii) Condensation polymers are biodegradable;

Can be hydrolysed by reaction with dilute acids/alkalis/water;

9 (a) (i) $Fe^{2+} + 2\bar{e} \rightleftharpoons Fe - 0,44\ V$
$Mg^{2+} + 2\bar{e} \rightleftharpoons Mg - 2,38\ V$
$Mg + Fe^{2+} \longrightarrow Mg^{2+} + Fe$;

$E^{\theta}cell = -0,44(-2,38)$

$= +1,94\ V$;

use or reduction polen have have is required in order to answer fully the questions
Reaction feasible so Mg corrodes in place of Fe.

(ii) $Fe^{2+} + 2\bar{e} \rightleftharpoons Fe - 0,44\ V$
$Zn^{2+} + 2\bar{e} \rightleftharpoons Zn - 0,76\ V$
$Fe^{2+} + Zn \longrightarrow Fe + Zn^{2+}$;

$E^{\theta}cell = -0,44 - (-0,76)$

$= +0,32\ V$;

(Reaction feasible so Zn corrodes in place of Fe.)

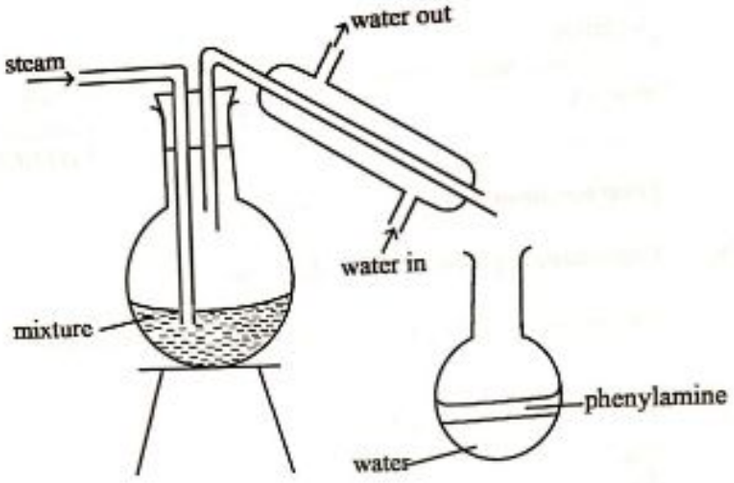
(iii) $Fe^{2+} + 2\bar{e} \rightleftharpoons Fe - 0,44\ V$
$Sn^{2+} + 2\bar{e} \rightleftharpoons Sn - 0,14\ V$

$E^{\theta}cell = -0,44 - (-0,14)$

$= -0.30v$

∴ Reaction of Fe and Sn not feasible so Fe will rust.)

(b) (i)



Steam passes through the mixture;
Condenses releasing heat;
Heat released is enough to boil the water and phenylamine;
The phenylamine and water vapour mixture is condensed and collected;

The lowering of boiling point of the mixture is due to individual partial pressure equal to the external pressure

(ii) Steam distillation allows collection below Bpt;
enables distillation at lower temperature;
Phenylamine **does not** decompose below Bpt;

(c) (i) (pale) blue;

(ii) $[Cu(OH)_2(H_2O)_4]$ /$Cu(OH)_2$;

(iii) $[Cu(H_2O)_2(NH_3)_4]^{2+}$;/ $[Cu(NH_3)_4]^{2+}$

10 (a) Recycling becomes more efficient;
Disposal becomes easier and safer;

(b) Leading of heavy metals;
Contamination of ground by leachates;
Production of toxic landfill gases (H_2S; CH_4) running out of space
Bad odour;
Green house gases;

(c) (i) - has a large surface area than the convectional form
- ability to cross cell membrane faster smell in sized particles

(ii) 1. - has a dimension ≤ nm;

2. A - graphene
B - graphite

(d) exposure to dust leading to respiratory problems; inhalation exposure;
potentially poisonous;
causes damage to body organs;
ingestion exposure;
fire and explosion;
cancer.

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Ordinary Level

CHEMISTRY

6031/4

2 hours 30 minutes

Paper 4 Practical Test

JUNE 2019

Detailed Identities of Chemicals Required

The identities of the chemicals with FA code numbers are as follows:

FA4 is a mixture of 0.2 moldm^{-3} $Al(NO_3)_3$ and 0.2 moldm^{-3} $Zn(SO)_4$.

Use equal volumes of the reagents.

FA1 is a mixture of 3.55 g of $NaHCO_3$ and 7.65 g of Na_2CO_3 dissolved in 1 dm^3 of distilled water.

[*10 cm^3 of FA1 requires about 5 cm^3 of the 0.15 moldm^{-3} HCl to reach end point using phenolphthalein indicator.*]

1 You are required to determine the proportions of $XHCO_3$ and X_2CO_3 in a soda water beverage, **FA1**.

The beverage, **FA1**, reacts with $HCl_{(aq)}$ in two steps as follows:

Step 1: $X_2CO_{3(aq)} + HCl_{(aq)} \longrightarrow XHCO_{3(aq)} + XCl_{(aq)}$

Step 2: $XHCO_{3(aq)} + HCl_{(aq)} \longrightarrow CO_{2(aq)} + H_2O_{(l)} + XCl_{(aq)}$.

(a) Pipette 25 cm^3 of **FA1** into a conical flask.

Add three drops of phenolphthalein indicator.

Titrate against 0.15 $moldm^{-3}$ $HCl_{(aq)}$ until the first end point.

Add three drops of methyl orange indicator.

Continue with the titration to the second end point.

Record the burette readings in **Table 1.1**.

Repeat the titration as many times as necessary to obtain accurate results.

Table 1.1

	1		2			
indicator used	**Ph**	**Mo**	**Ph**	**Mo**		
final burette reading/ cm^3						
initial burette reading/ cm^3						
volume of HCl /cm^3						

Key: **Ph** = **Phenolphthalein**
Mo = **Methylorange**

[14]

(b) Calculate the average titre for the titration with

(i) phenolphthalein,

(ii) methyl orange, [2]

(c) Calculate the

(i) number of moles of $HCl_{(aq)}$ used in the titration with phenolphthalein, [1]

(ii) number of moles of X_2CO_3 in the 25cm^3 of **FA1**, assuming that the reaction that took place is

$$Na_2CO_3 + 2HCl \rightarrow CO_2 + 2NaCl + H_2O$$ [1]

(iii) mass of X_2CO_3 in 25 cm^3 of **FA1**

[Ar: X =39.1; C = 12; 0 =16]

[1]

(iv) number of moles of HCl that reacted with the original $XHCO_3$ in 25cm^3 of **FA1** [2]

(v) number of moles of original $XHCO_3$ in 25cm^3 of **FA1**. [1]

(vi) mass of $XHCO_3$ in 25 cm^3 of **FA1**. [1]

(d) Deduce the ratio $XHCO_3 : X_2CO_3$ in the beverage. [1]

(e) State and describe the possible healthy benefits of drinking soda water beverages. [2]

ASSESSMENT OF PLANNING SKILLS

DO NOT CARRY OUT YOUR PLAN.

2 An inorganic fertiliser consists of a mixture of $NH_4NO_{3(s)}$ and $CaO_{(s)}$. When the fertiliser dissolves in water the environmental temperature of the plant roots must remain constant.

Devise a sequence of numbered steps to find the masses of $NH_4NO_{3(s)}$ and $CaO_{(s)}$ which when mixed homogeneously, dissolved into 25 cm^3 distilled water the temperature change (ΔT) is zero.

Assume you are provided with the following:

thermometer
electronic balance
100 cm^3 plastic cups
50 cm^3 measuring cyclinder
distilled water
spatula
5 g of ammonia nitrate
5 g of calcium oxide

The plan

3 **FA4** contains **two** cations and **two** anions.

Carry out the tests described in the table to identify the cations and anions in **FA4**.

In all the tests, the reagents should be added gradually until no further change is observed. Observations made and recorded as they occur.

Record your observations and deductions in the spaces provided.
Your answers should include,

(i) details of colour changes and precipitates formed,

(ii) description of gases evolved and details of the tests used to identify them.

You should indicate clearly at what stage in a test a change occurs writing any deductions you may make alongside the observation on which they are based.

	test	observations	deductions
(a)	To a portion of **FA4** add $NaOH_{(aq)}$, until in excess. Gently boil the mixture then add *Al* foil		

	test	observations	deductions
(b)	To a portion of **FA4**, add $NH_{3(aq)}$, until in excess.		
(c)	To a portion of **FA4** add $Ba(NO_3)_{2(aq)}$, followed by nitric acid.		

	test	observations	deductions
(d)	To a portion of **FA4**, add aqueous KI.		

Summary:

Anions present in **FA4** are _____ and _____

Cations present in **FA4** are _____ and _____

[Total: 15]

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED ANSWERS AND SOLUTIONS

JUNE 2019

CHEMISTRY **6031/4**

1 (a) (i) Titration table

- All readings must read to 2.d.p but not more than 1zero start.
- At least two titres within 0.2 diff, either for Ph or Mo

(b) (i) $\frac{Ph1 \quad Ph2 \quad Ph3}{\text{titre (1a)} + \text{titre (2a)} + \text{titre 3a+}\cdots}{\text{number of titres}}$

(ii) $\frac{MO_1 \quad MO_2 \quad MO_3}{\text{titre (1b)} + \text{titre (2b)} + \text{titre 3b+}\cdots}{\text{number of titres}}$

(c) (i) $\frac{Phtitre \times 0.15}{1\,000}$

(ii) Answer c(i) $\times \frac{1}{2}$

(iii) Answer to c(ii) $\times$ 138.2

(iv) $\left(\frac{MOtitre \times 0.15}{1000}\right)$ – answer c(ii)

(v) Answer c(iv)

(vi) ans(v) $\times$ 100

(d) ans c(v) : answer c(ii) simplified

(e) neutralises excess stomach acids, hydration/reduces tooth decay

2 Step 1: Weigh plastic cup by placing on the balance

Step 2: Weigh the following masses of $NH_4NO_3(s)$ and CaO(s)

mixture number					
$M(NH_4NO_3)$g	1.0	1.0	1.0	1.0	1.0
M(CaO)/g	0	0.5	1.0	1.5	2.0

Step 3: Add each of $m(NH_4NO_3)$ into m(CaO)

Step 4: Place 25 cm^3 distilled water into a measuring cylinder

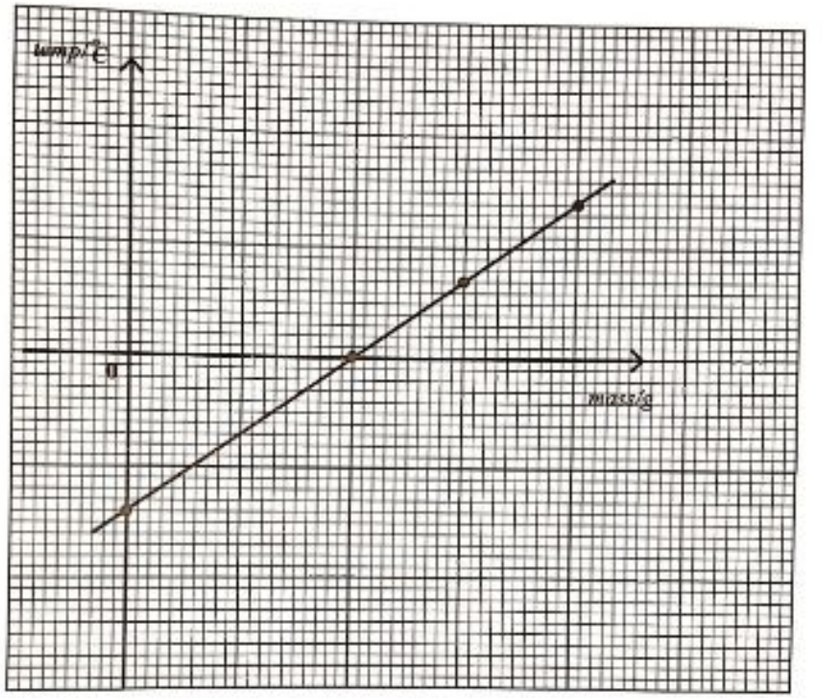
Step 5: Insert thermometer, (stir gently) and record initial temperature.

Step 6: Add the water into mixture 1 and record the highest temp or lowest temp.

Step 7: Repeat procedures in Step 4-6 for mixtures 2-4 recording the results.

Step 8: Calculate ΔT for each mixture as Final temp – Initial temp

Step 9: Plot a graph of ΔT against mass mixtures.



Step 10: Extrapolate the mass of CaO from the graph which must be mixed with 2.0 g (NH_4NO_3)

3

	Test	Observation	Deduction
(a)	FA4 + excess NaOH	White ppte soluble [1]	$Al^{3+}Pb^{2}Zn^{2+}$ Ca^{2+}
	Boiling	No observable change [1]	NH_4^+ absent
	+A1 foil	Pungent smelling gas bubbles turns damp red litmus blue [1]	NO_3^- / NO_2^-
(b)	FA4 + excess NH_3	White ppte soluble [1]	Pb^{2+} $A1^{3+}$ Zn^{2+} Zn^{2+}
(c)	FA5 + $Ba(NO_3)_2$ + HNO_3	White ppte soluble [1] Insoluble white ppt	SO_3^{2-} SO_4^{2-} SO_3^{2-}
(d)	FA4 + $KI_{(aq)}$	No observable change	Pb^{2+} absent

Anions present are NO_3^-/NO_2^- and SO_4^{2-} ____

Cations present are Al^{3+} and Zn^{2+}

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

CHEMISTRY

PAPER 1 Multiple Choice

6031/1

NOVEMBER 2019 SESSION

1 hour

Additional materials:
- Data Booklet
- Scientific/Electronic calculator
- Multiple Choice answer sheet
- Soft pencil (type B or HB is recommended)

TIME 1 hour

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your name, Centre number and candidate number on the answer sheet in the spaces provided unless this has already been done for you.

There are **forty** questions in this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider correct and record your choice in soft pencil on the separate answer sheet.

Read very carefully the instructions on the answer sheet.

INFORMATION FOR CANDIDATES

Each correct answer will score **one** mark. A mark will **not** be deducted for a wrong answer.
Any rough working should be done in this booklet.

Section A

*For each question there are four possible answers, **A, B, C** and **D**. Choose the one you consider to be correct.*

1 What is the volume of oxygen gas produced, measured at s.t.p, when 2.5 A is passed through dilute sulphuric acid for 1 850 seconds using platinum electrodes?

A 268.40 cm^3
B 536.79 cm^3
C 1 073.00 cm^3
D 1 149.60 cm^3

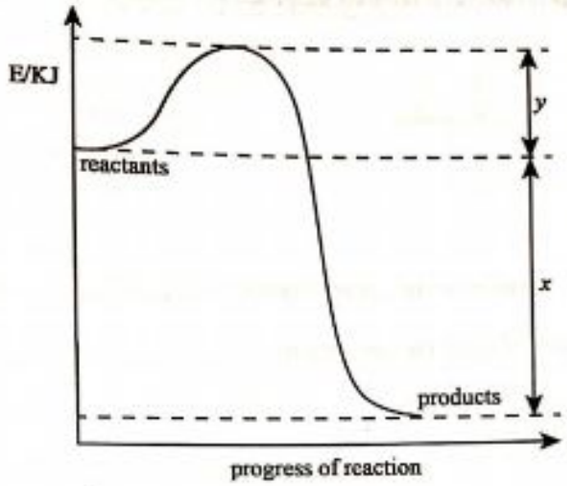
2 A volume of 15.00 cm^3 of 0.040 $moldm^{-3}$ lead (II) nitrate was mixed with 15.00 cm^3 of 0.040 $moldm^{-3}$ sodium chloride.

$$[K_{sp}: PbCl_{2(s)} = 1.7 \times 10^{-5}]$$

Which statement gives the correct result?

A a clear solution with no precipitate is formed.
B $PbCl_2$ precipitates and excess Pb^{2+} ions will remain in solution
C $PbCl_2$ precipitates and excess Cl^- ions will remain in solution.
D $PbCl_2$ precipitates, and no excess ions will remain in solution.

3 An energy diagram for a reaction is shown:



The activation energy of the reverse reaction is given by the value of

A x.

B y.

C $x + y$.

D $x - y$.

4 A 0.10 moldm^{-3} solution of a weak acid, HA, has a pH of 4.8.

What is the value of pKa?

A 3.8
B 4.8
C 8.6
D 9.6

5 What is the percentage of ^{71}Ga given that its isotopes ^{69}Ga and ^{71}Ga have a relative isotopic mass of 69.8?

A 0.4%
B 0.6%
C 40%
D 60%

6 Flask A contains 2 dm^3 of helium at 4 kPa and flask B contains 4 dm^3 of neon at 2 kPa.

If the flasks are connected at constant temperature, the final pressure is

A $\frac{2}{3}$ kPa

B $\frac{4}{3}$ kPa

C $\frac{5}{3}$ kPa

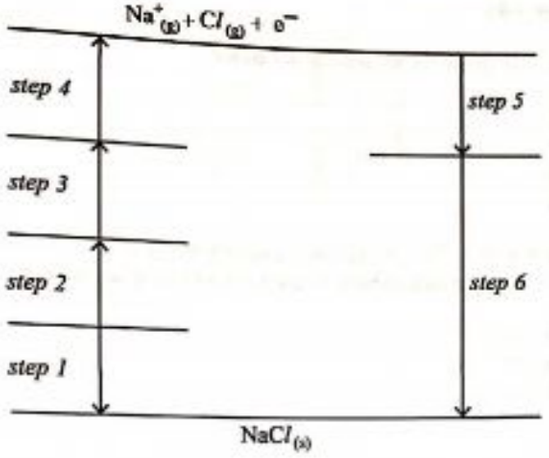
D $\frac{8}{3}$ kPa

7 The given equilibrium exists in a gaseous system: $2X_{(aq)} \rightleftharpoons Y_{(aq)} + 2Z_{(aq)}$.

What are the units of K_c for the equilibrium?

A mol^2dm^{-6}
B $mol^{-2}dm^6$
C $moldm^{-3}$
D $mol^{-1}dm^3$

8 The diagram shows the Born-Haber cycle of NaCl.



Which set correctly shows the chemical equations for steps 1 and 6?

	1	6
A	$2Na_{(s)} + Cl_{(g)} \rightarrow 2NaCl_{(s)}$	$2Na^+_{(g)} + 2Cl^-_{(g)} \rightarrow 2NaCl_{(s)}$
B	$Na^+_{(s)} + \frac{1}{2}Cl^-_{2(g)} \rightarrow NaCl_{(s)}$	$Na^+_{(g)} + Cl^-_{(aq)} \rightarrow NaCl_{(s)}$
C	$Na_{(s)} + \frac{1}{2}Cl_{2(g)} \rightarrow NaCl_{(s)}$	$Na^+_{(g)} + Cl^-_{(g)} \rightarrow NaCl_{(s)}$
D	$Na^+_{(g)} + \frac{1}{2}Cl_{2(g)} \rightarrow 2NaCl$	$NaCl_{(s)} \rightarrow Cl^+_{(aq)} + \frac{1}{2}Cl_{2(g)}$

9 A mass of 1.00 g of NH_4Cl was dissolved in 30.00 cm^3 of 3.00 $moldm^{-3}$ NH_3.

$[K_b: (NH_3) = 1.8 \times 10^{-5}]$

What is the $[H_3O^+]$ in the solution formed?

A 5.5×10^{-10} $moldm^{-3}$
B 2.7×10^{-9} $moldm^{-3}$
C 1.2×10^{-10} $moldm^{-3}$
D 1.4×10^{-12} $moldm^{-3}$

10 An electric current was passed through molten calcium chloride, producing 2.0 g of calcium metal at the cathode.

What mass of chlorine was produced at the anode?

A 1.78 g
B 3.55 g
C 4.00 g
D 7.10 g

11 Which two substances will remain, when a sample of an alloy of tin and lead is heated in excess oxygen and allowed to cool at room temperature?

A Sn and PbO
B SnO and Pb
C SnO and PbO_2
D SnO_2 and PbO

12 Aluminium oxide is dissolved in molten cryolite during the extraction of aluminium by electrolysis because the cryolite

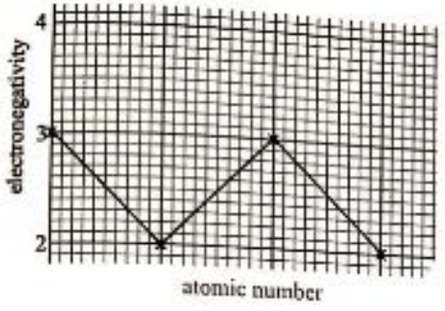
A provides the ions needed to carry the current.
B reduces the high melting point of the electrolyte.
C reacts with the aluminium oxide to form ions.
D removes impurities in the alumimium oxide.

13 The compound PCl_5 is known, but no chemist has been able to make NCl_5 because

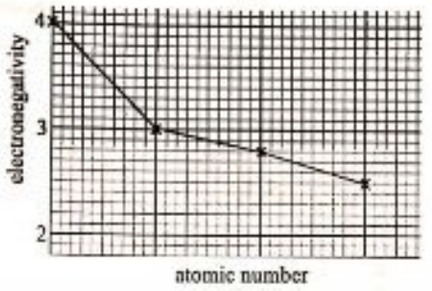
A the covalent bond in the nitrogen molecule is too strong.
B nitrogen does not have d orbitals in its valence shell.
C nitrogen chloride covalent bonds are very weak.
D nitrogen has only two orbitals in its outer shell.

14 Which graph shows the correct trend in electronegativity down a group?

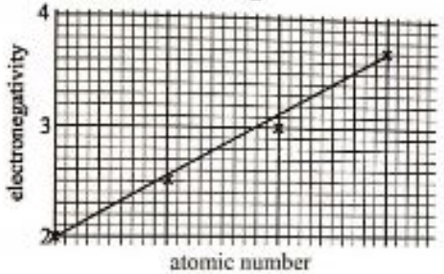
A



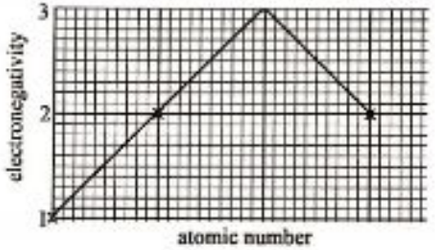
B



C



D



15 Ethene and butane are similar in that they

A burn in oxygen to produce water and carbon dioxide.
B are hydrogenated using a suitable catalyst.
C polymerise under suitable conditions.
D are obtained by the dehydration of alcohols.

16 Which one is a termination step in the reaction between ethane and chlorine?

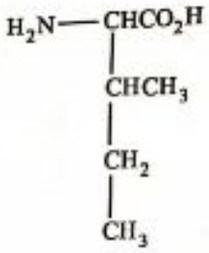
A $CH_3CH_2\bullet + Cl\bullet \longrightarrow CH_3CH_2Cl$

B $Cl_2 \longrightarrow Cl\bullet + Cl\bullet$

C $CH_3CHCl\bullet + Cl_2 \longrightarrow CH_3CHCl_2 + Cl\bullet$

D $CH_3CH_2\bullet + Cl_2 \longrightarrow CH_3CH_2Cl + Cl\bullet$

17 What type of isomerism is shown by the organic compound of the structure



A geometric
B positional
C optical
D structural

18 Which one is **not** a product of the reaction of methane with chlorine in the presence of U.V light?

A 1-chloropropane
B dichloromethane
C trichloromethane
D chloroethene

19 Why is phenylamine a weaker base than ethylamine in water?

A Phenylamine is less soluble in water.
B Phenylamine does not form hydrogen bonds with water.
C In phenylamine, the protons are attracted to the benzene ring rather than to the nitrogen atom.
D In phenylamine, the lone pair of electrons on the nitrogen atom is delocalised.

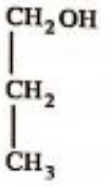
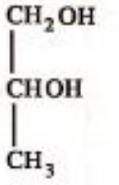
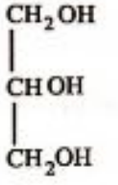
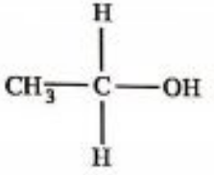
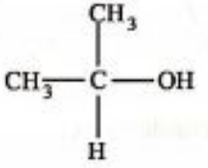
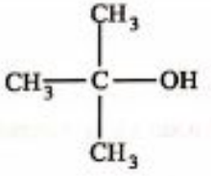
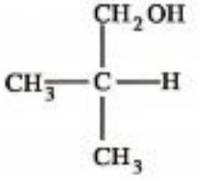
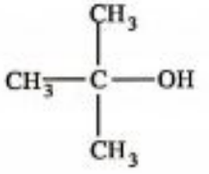
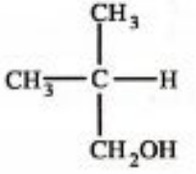
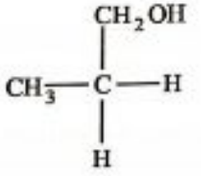
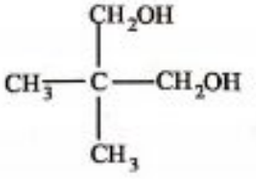
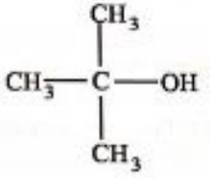
20 The mechanism involved when chlorine reacts with propene in an organic solvent is

A electrophilic addition.
B electrophilic substitution
C nucleophilic addition
D nucleophilic substitution

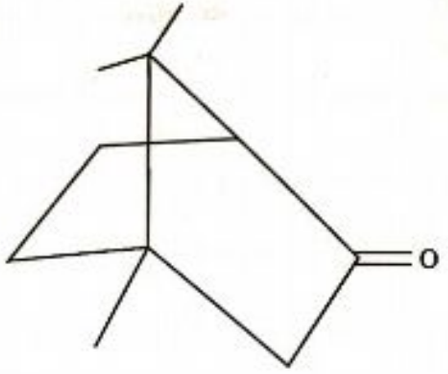
21 Which property can be used to identify the organic compounds of molecules with formula C_3H_9N.

A chirality
B solubility
C reactions with C_2H_5COOH.
D reactions with $NaNO_2$.

22 Which set of alcohols correctly shows a primary, a secondary and a tertiary alcohol?

	primary	secondary	tertiary
A			
B			
C			
D			

23 The skeletal structure of camphor is shown.



How many chiral centres does camphor have?

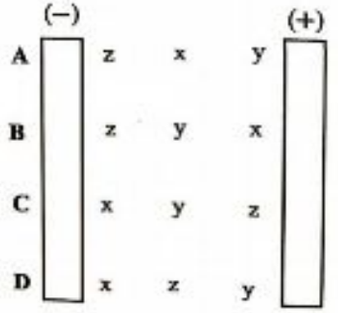
A 0
B 1
C 2
D 3

24 How many different aldehydes have the molecular formula $C_5H_{10}O$?

A 2
B 3
C 4
D 5

25 The isoelectric pH of three amino acids, X, Y and Z, are 7.50, 6.00 and 4.50, respectively.

What is the correct arrangement of the amino acids during electrophoresis when buffered at a pH of 6.00?



26 Which one is an effect of water pollution by oil in seas?

A increase in the sea level
B reduction in marine species
C reduction in global warming
D increase in eutrophication

27 Which pollutant is formed in the internal combustion engine and leads to the formation of acid rain?

A Carbon monoxide
B Carbon
C Nitrogen monoxide
D Sulphur dioxide

28 Nano materials **cannot** exist in the form of

A suspensions.
B liquids.
C colloids.
D solids.

29 Which one is **not** a Platinum Group Metal (PGM)?

A osmium
B ruthenium
C rhodium
D cadmium

30 The $[Cu(H_2O)_6]^{2+}$ ion is blue whereas $[CuCl_4]^{2-}$ ion is yellow.

Which statement explains the difference in colour?

A difference in the number of electrons in copper
B difference in shapes of the complex ions
C difference in the energy gaps between the d-orbitals
D difference in the charge of the complex ions

Section B

For each of the questions in this section, one or more of the three numbered statements 1 to 3 may be correct.

Decide whether each of the statements is or is not correct. (You may find it helpful to put a tick against the statement(s) which you consider to be correct).

The responses A to D should be selected on the basis of

A	B	C	D
1, 2 and 3 are correct	*1 and 2 only are correct*	*2 and 3 only are correct*	*1 only is correct*

No other combination of statements is used as a correct response.

31 Which molecule(s) is/are linear in shape?

4. $BeCl_2$

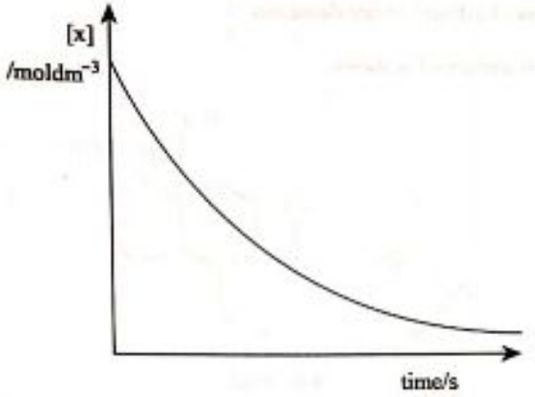
5. CO_2

6. Cl_2O

32 The reaction shown was found to be first order:

$$X \longrightarrow \text{Products.}$$

The graph shows how the [X] varied with time.



The graph can be used to determine the

4. rate of reaction at any given time.
5. order of reaction.
6. half-life of the reaction.

33 Which metal(s) is/are deposited at the cathode when 290 C of electricity are passed through 1×10^{-3} moles of a molten compound?

4. aluminium
5. chromium
6. sodium

34 Ammonium sulphate can be prepared by the reaction:

$$SO_3 + H_2O + 2NH_3 \longrightarrow (NH_4)_2SO_4$$

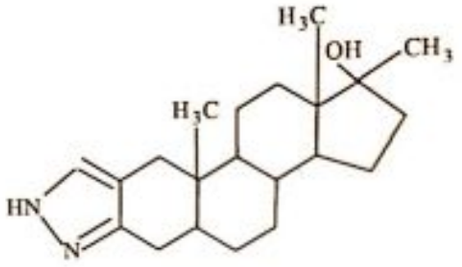
What occurs during this reaction

4. acid/base neutralisation.
5. dative bond formation.
6. redox reaction.

35 What happens when calcium nitrate decomposes?

1. a colourless gas is observed
2. a gas that relights a glowing splint is produced
3. the mass of calcium nitrate decreases

36 The structure of stanozolol is shown.



stanozolol

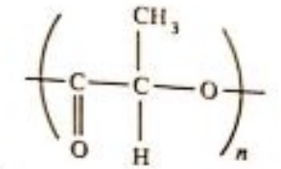
Which statement(s) about stanozolol is/are correct?

4. It has 2 chiral centres.
5. It is a tertiary alcohol.
6. It decolourises $KMnO_4$.

37 The molecular formula of lactic acid is $CH_3CH(OH)COOH$.

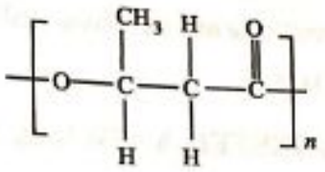
Which statement is/are true about lactic acid?

1. It can be oxidised to a lactone
2. It can polymerise to form



3. It shows geometrical isomerism

38 The polymer shown occurs in bacteria as cell storage material.



Which deduction(s) about this substance can be made from the structure?

4. It is a polyester.

5. It could be readily made from $HOCH_2CH_2CH_2CO_2H$.

6. It reacts with phosphorus pentachloride to give fumes of hydrogen chloride.

39 The outer electronic structure of an element is $3d^5 4s^2$.

The element

4. forms coloured ions.

5. forms complex ions.

6. has a low melting point.

40 The benefit(s) of reusing waste is/are

4. reduces costs of waste disposal

5. reduces environmental damage

6. saves energy

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Ordinary Level

CHEMISTRY PAPER 1 6031/1

NOVEMBER 2019 SUGGESTED ANSWERS AND SOLUTIONS

Question number	key	comment
1	A	The reaction occurring at the anode $4OH^- \longrightarrow O_2 + 2H_2O + 4\bar{e}$ notes of oxygen $= \frac{1\epsilon}{2F} = \frac{2.5 \times 1850}{4 \times 96\,500}$ Volume $= \frac{2.5 \times 1850}{4 \times 96\,500} \times 224 = 268.40cm^3$
2	B	If ionic product = or < solubility product precipitation will occur.
3	C	
4	C	
5	C	
6	D	Boyles law $P_1V_1 = P_2V_2$ V_2 = Total volume $(4)(2) = P_2(6)$ $P_2 = \frac{8}{6}$ for neon and same for helium Total pressure $\frac{8}{6} + \frac{8}{6} = \frac{8}{3} kPa$
7	C	
8	C	Δ H formation – one mole of a compound (crystalline) starting of constituent elements under standard condition
9	C	
10	B	
11	D	Pb_2O is more slable than PbO_4
12	B	
13	B	N can not extend its octet structure compared with P $(no\ d-orbitals)$
14	B	
15	A	

16	A	free radicals combine during termination stage
17	C	
18	D	
19	D	
20	A	
21	B	
22	B	
23	C	chiral centres are two instead of three because the other carbon has two methyl groups
24	C	
25	C	If pH = Isolectric $pH \Longrightarrow$ no net migration $Ph >$ Isolectric $PH \Longrightarrow$ the amino acid is positive and moves to the negative $Ph <$ Isolectric $PH \Longrightarrow$ the amino acid is negative and moves to the positive
26	B	oil spills kill aquatic animal and plants
27	C	Nitrogen monoxide is produced because of high temperature in car engine and is responsible for formation of acid rain
28	B	
29	D	Platinum Group Metals – osmium, ruthenium, Rhodium, Platinum, Iridium, Palladium
30	C	
31	B	use VSPER to predict shapes of covalent compounds.
32	A	
33	B	
34	B	no redox reaction, oxidation state of S and N remain unchanged
35	C	
36	C	
37	B	lactone – an organic compound containing an ester group as part of a ring

38	D	
39	B	
40	A	

Candidate Name

Centre Number	Candidate Number

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL
General Certificate of Education Advanced Level

CHEMISTRY **6031/2**
PAPER 2

NOVEMBER 2019 SESSION 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Data Booklet
Electronic Calculator

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer all questions.
Write your answers in the spaces provided on the question paper.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE	
1	
2	
3	
4	
5	
6	
TOTAL	

Answer all questions

1 (a) **Fig. 1.1** shows a set up used to analyse the composition of an organic compound, **M.**

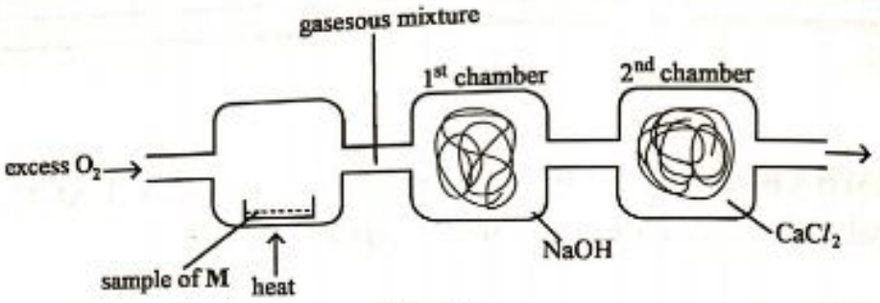


Fig. 1.1

(i) Name **two** gases present in the gaseous mixture other than oxygen.

1. _____

2. _____

(ii) Describe the function of the

1. 1st chamber,

_____

2. 2ad chamber.

_____

(iii) Explain why excess oxygen is added into the furnace.

_____

_____

_____ [5]

(b) An organic compound, **Y**, consists of the elements carbon, hydrogen and chlorine only. Combustion of 0.02 g of **Y** produced 0.0177 g of carbon dioxide and 0.0072 g of water.

(i) Determine the empirical formula of **Y**.

(ii) Deduce the molecular formula of **Y**, given that its relative molecular mass is 98.96.

[5]
[Total:10]

2 Hydrogen reacts with iodine, at constant temperature, according to the equation:

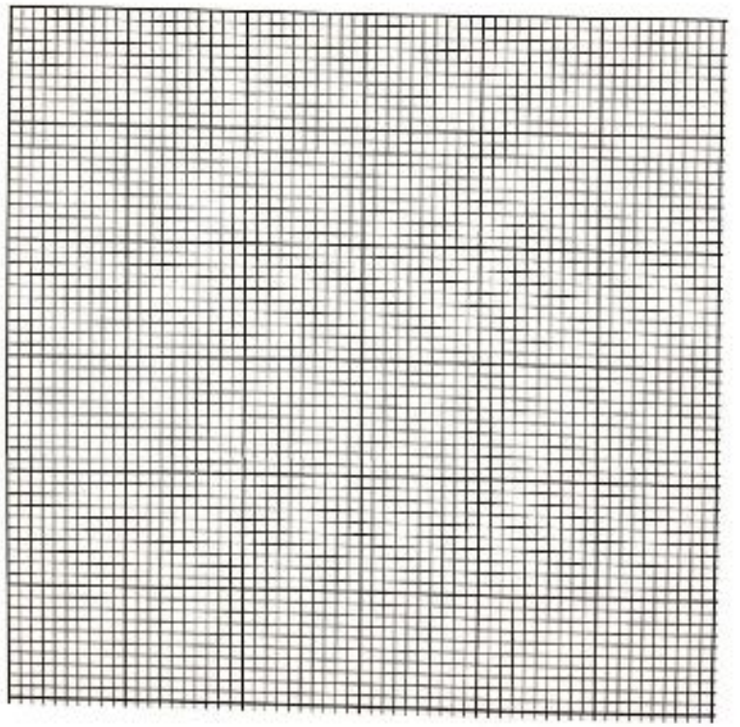
$$H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$$

Table 1.1 shows the results of experiments used to investigate the kinetics of the reaction.

Table 1.1

experiment	concentration of hydrogen/moldm^{-3}	rate of reaction/moldm^{-3}s^{-1}
1	1.0×10^{-3}	6.0×10^{-7}
2	2.0×10^{-3}	1.2×10^{-6}
3	3.0×10^{-3}	1.8×10^{-6}
4	4.0×10^{-3}	2.4×10^{-6}

(a) (i) Plot a graph of rate of reaction against concentration of hydrogen.



(ii) State, with a reason, the order of the reaction with respect to hydrogen.

_____

_____

_____

(iii) Deduce the rate of the reaction when the concentration of hydrogen is 2.5×10^{-3} moldm^{-3}.

_____

_____

[6]

(b) Sketch on the same axis, the graph obtained if the reaction is second order with respect to hydrogen. Label the graph **L**. [1]

(c) (i) The concentration of iodine used in **experiment 1** was 3.0×10^{-3} moldm^{-3}.

Calculate the rate constant, given that the overall order of the reaction is 2.

(ii) **Experiment 5** was carried out using 5.0×10^{-3} moldm^{-3} $H_{2(g)}$ and 6.0×10 moldm^{-3} $I_{2(g)}$.

Calculate the rate of the reaction in this experiment.

[3]
[Total:10]

3 (a) The oxide of gallium reacts with strong alkali to form a solution of the gallate ion, $Ga(OH)_4^-$ and with HCl to form gallium trichloride.

(i) Write the formula of gallium oxide.

(ii) Describe and explain how gallium oxide reacts with water.

(iii) Suggest why gallium oxide is useful in making ceramic structures.

(iv) Write a balanced chemical equation for the reaction of gallium oxide with HCl.

[6]

(b) Explain why

(i) aluminium pans can be safely heated on a gas cooker,

(ii) P_4O_{10} can be vapourised by gentle heat but SiO_2 cannot.

[4]

[Total:10]

4 **Fig. 4.1** shows a part of polylactide, a polymer, made from garbage waste.

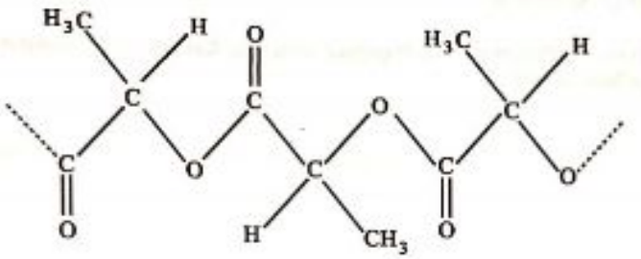


Fig. 4.1

(a) **(i)** Draw the structural formula of the monomer of polylactide.

(ii) Name the type of polymerisation that forms polylactide.

_____

(iii) Explain why there are different forms of polylactides.

_____

_____

_____

[6]

(iv) Suggest and explain any **two** advantages of using polylactide for producing packaging material.

1. _____

_____

2. _____

_____

[7]

(b) Boiling points of organic compounds of molecular formula C_3H_9N range from 3 °C to 48 °C.

Deduce, with reasons, the displayed structural formula of the compound that boils at 3 °C.

reasons _____

_____

_____

_____

[3]

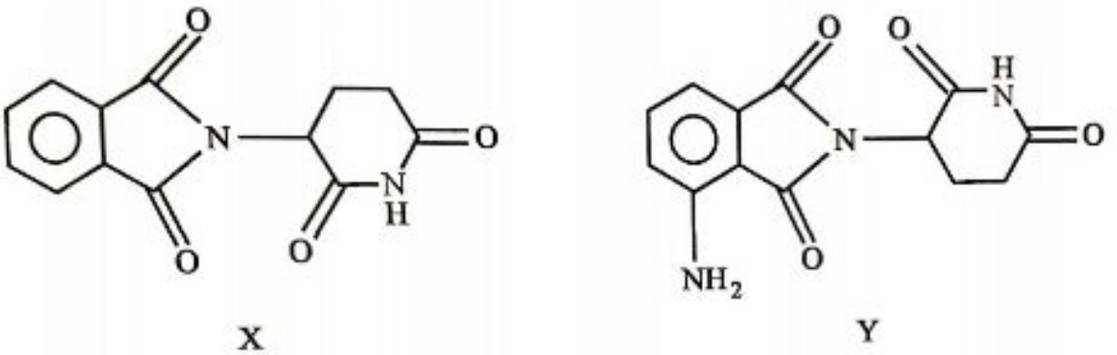
[Total: 10]

5 **(a)** Name any **two** forms of isomerism shown by an organic compound of molecular formula C_3H_6O.

1. _____

2. _____ [2]

(b) **Fig. 5.1** shows the structure of two organic compounds, X and Y.



X Y

Fig. 5.1

Describe a chemical test that can be used to distinguish between X and Y.

_____

_____

_____

_____ [3]

(c) **Fig. 5.2** shows how compound **Z** can be synthesised.

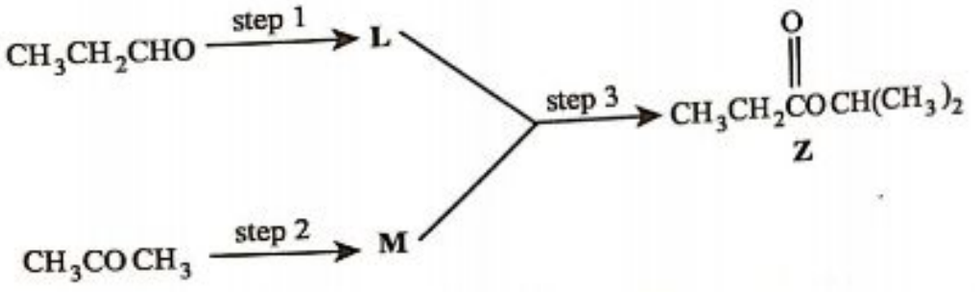


Fig. 5.2

(i) Identify compounds **L** and **M**.

L _____

M _____ [2]

(ii) Complete **Table 5.1** by stating the type of reaction, reagents and conditions used for step 3.

Table 5.1

type of reaction	reagent(s)	condition(s)

[3]

[Total:10]

6 (a) (i) Give **one** example of

1. organic nanoparticles,

2. inorganic nanoparticles.

(ii) Explain the application of nanotechnology in the control of water pollution.

[5]

(b) (i) Describe and explain observations made when aqueous ammonia is added to $[CuCl_4]^{2-}$ until in excess.

(ii) Write an equation for the formation of $[Cu(NH_3)_4]^{2+}$ from $[Cu(H_2O)_6]^{2+}$.

[5]
[Total:10]

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED SOLUTIONS

NOVEMBER 2019

CHEMISTRY

6031/2

1 (a) (i) 1. Carbon dioxide;

2. Water varpour;

(ii) 1st chamber – to absorb carbon dioxide;
2nd chamber – to absorb water vapour;

(iii) - to ensure complete combustion;

(b) (i) 1. $\frac{12}{44} \times \frac{0.0177}{0.02} \times \frac{100}{1} = 24.2\%$ C

2. $\frac{2}{18} \times \frac{0.0072}{0.02} \times \frac{100}{1} = 4\%$ H

3. $[100\% - (1 + 2)] = 71.8\%$ *Cl*

C	H	*Cl*
$\frac{24.2}{12.01}$	$\frac{4}{1.004}$	$\frac{71.8}{35.5}$
2.01	3.98	2.02
$\frac{2.01}{2.01}$	$\frac{3.98}{2.01}$	$\frac{2.02}{2.01}$
1	1.98	1.00

Empirical formula CH_2Cl

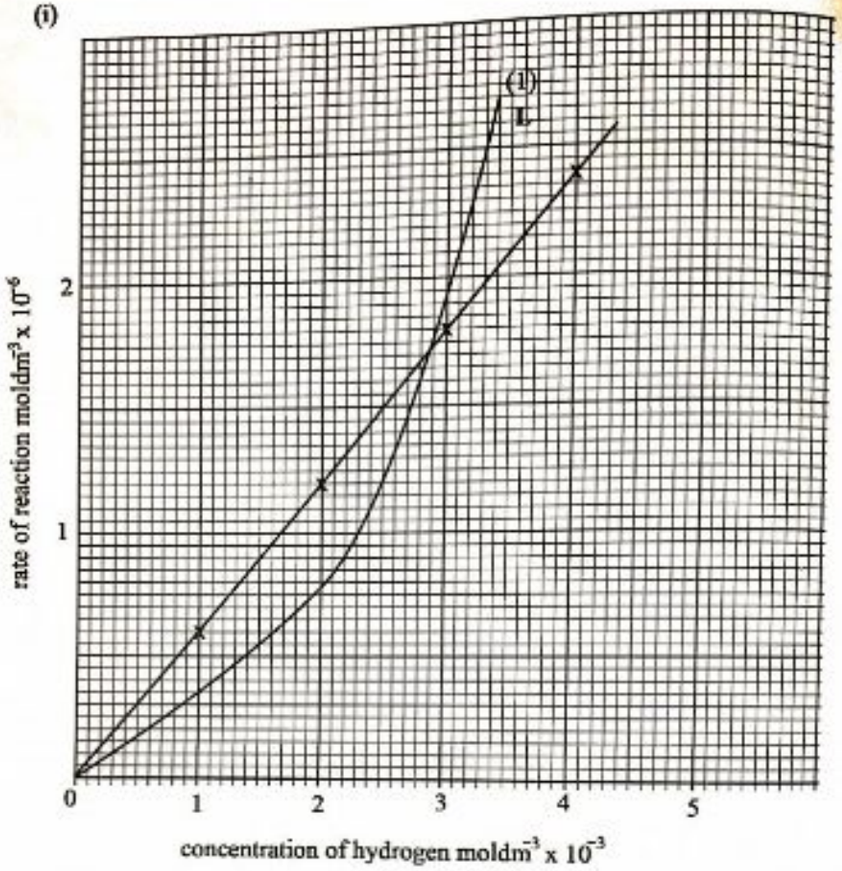
(ii) $n(CH_2Cl) = 98.96$

$12.0\,n + 2n(1.00) + 35.5n = 98.96$

$n = 2$

$C_2H_4Cl_2$

2 (a) (i)



(ii) 1st order;
doubling concentration doubled rate/the graph is a straight line;

(iii) $1.5 \times 10^{-6}\text{moldm}^{-3}\text{s}^{-1}$

(b) on the graph

(c) (i) $6.0 \times 10^{-7} = k(1.0 \times 10^{-3})(3.0 \times 10^{-3})$

$k = 0.2$; (1)

units $\text{mol}^{-1}\text{dm}^3\text{s}^{-1}$ (1)

(ii) Rate = $(0.2)(5.0 \times 10^{-3})(6.0 \times 10^{-3})$

= $6.0 \times 10^{-2}\text{moldm}^{-3}\text{s}^{-1}$

3 (a) (i) Ga_2O_3;

(ii) $Ga_2O_3 + H_2O \rightarrow$ no reaction;

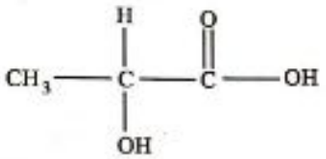
(iii) thermally stable / high m.p.t reacts under harsh conditions;

(iv) $Ga_2O_{3(s)} + 6HCl_{(aq)} \longrightarrow 2GaCl_{3(aq)} + 3H_2O_{(l)}$

(c) (i) Al readily reacts with oxygen forming Al_2O_3 which has a very high mpt and coats on the surface of the pan;

(ii) P_4O_{10} is simpler molecular;
SiO_2 is giant molecular;
more heat is required to break the very strong covalent bonds;

4 (a) (i)

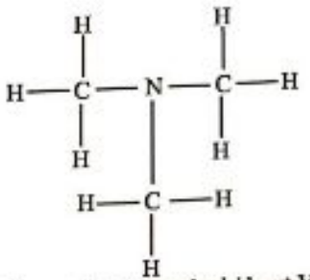


(ii) Condensation;

(iii) Lactic acid – isomers (polymer forms optical isomers)
Ethene – no isomers

(iv) biodegradable; easy to dispose;
reduces pollution of environment;
can be hydrolysed to monomers;
cab be recycled
cheaper drawn from waste raw material
obtained from renewable materials sources/natural
assured of continuous supply/will not run out of supply

(b)



Tertiary amine / branched / least Van Der Waals forces

No hydrogen bonding;

5 (a) functional group isomerism;
cis/trans/geometric,
positional

(b) react with acidified $NaNO_2$;
followed by phenol;
Y gives a coloured azo compound;
X no observable change;

(c) (i) L CH_3CH_2COOH/ propanoic acid
M $CH_3CH(OH)CH_3$/ prop -2-ol

(ii) Conditions; esterification/condensation/ addition – elimination;
acid catalyst/conc H_2SO_4;
reflux / heat/ boil;

Reagents: CH_3CH_2COOH/ propanoic acid
$CH_3CH(OH)CH_3$/ prop -2-ol

6 (a) (i) Inorganic: metal oxide/metal nanoparticles/graphene nanotubes/bucky balls; fullerene

Organic: polymer nanoparticles/nanogels/dendrimers

(ii) Ion exchange resins from nanoparticles for purification and softening of water; deionization of water using nano-sized fibres and electrodes; use of KMnO nanomers to clean up oil and other pollutants; nanoparticles inserted in underground water;
nanosensors for impurity detection;
nano carbon tubes for micro filtration;

(b) (i) Observation: Light blue ppt
soluble in excess

Explanation: NH_3 is a stronger ligand than Cl^-/AW
NH_3 displaces Cl^- from Cu^{2+};

(ii) $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightleftharpoons [Cu(NH_3)_4]^{2+} + 6H_2O$ /

$Cu^{2+}(aq) + 4NH_{3(aq)} \rightleftharpoons [Cu(NH_3)_4]^{2+}_{(aq)}$

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL
General Certificate of Education Advanced Level

CHEMISTRY **6031/3**

PAPER 3

NOVEMBER 2019 SESSION 2 hours 30 minutes

Additional materials:
- Answer paper
- Data Booklet
- Electronic calculator

TIME: 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES

Write your name, centre number and candidate number in the spaces provided on the answer paper/answer booklet.

Answer **six** questions.

Answer **two** questions from Section A, **one** question from Section B, **two** questions from Section C and **one** question from Section D.

Write your answers on the separate answer paper provided.

If you use more than one sheet of paper, fasten the sheets together.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.

You are reminded of the need for clear presentation in your answers.

This question paper consists of 13 printed pages and 3 blank pages.

Section A

Answer any two questions from this section.

1 **(a)** **(i)** Draw a dot and cross diagram to show the bonding in dichlorodifluoromethane.

(ii) Deduce, with reasons, the shape of dichlorodifluoromethane.

[3]

(b) An organic compound of mass 0.120 g was oxidised to 0.176 g carbon dioxide and 0.072 g water. When 0.148 g of the organic compound was vaporised at 60 °C, the vapour produced occupied a volume of 67.700 cm^3 at a pressure of 101 kPa.

(i) Determine the molecular formula of the organic compound.

(ii) Draw the displayed structural formula of the organic compound.

[7]

(c) An indigestion tablet of mass 0.50 g was dissolved in distilled water. The resultant solution required 28.30 cm^3 of 0.15 $moldm^{-3}$ of hydrochloric acid for complete neutralisation. The active ingredient in the tablet was found to be magnesium hydroxide.

(i) State the role of the indigestion tablet.

(ii) Determine the percentage by mass of the active ingredient in the tablet.

[5]

[Total:15]

2 **(a)** During respiration in humans, carbon dioxide produced diffuses into the blood to form a mixture of H_2CO_3 and HCO_3^-. The mixture acts as a buffer in the blood.

(i) Explain the importance of the H_2CO_3 and HCO_3^- mixture in the blood.

(ii) Write equations to show the buffering action of the mixture.

(iii) Calculate the mass of $NaHCO_3^-$ present in a 250 cm^3 sample of the buffer given that the pH of the buffer is 5.94 and the concentration of H_2CO_3 is 0.5 $moldm^{-3}$.
[$K_a(H_2CO_3) = 4.6 \times 10^{-7}$ $moldm^{-3}$] [7]

(b) Ethanal and methanol react according to the equation:

$$CH_3CHO + 2CH_3OH \rightleftharpoons CH_3CH(OCH_3)_2 + H_2O$$

A 25.00 cm^3 mixture of the chemicals was found to contain 0.131 moles of CH_3CHO, 0.129 moles of CH_3OH, 0.0785 moles of $CH_3CH(OCH_3)_2$ and 0.0418 moles of H_2O.

(i) Calculate the K_c value, given that at equilibrium the amount of CH_3OH was found to be 0.0638 moles.

(ii) Describe and explain how the amount of $CH_3CH(OCH_3)_2$ can be increased.

[8]
[Total:15]

(a) **Fig. 3.1** shows the trend in the ionisation of magnesium.

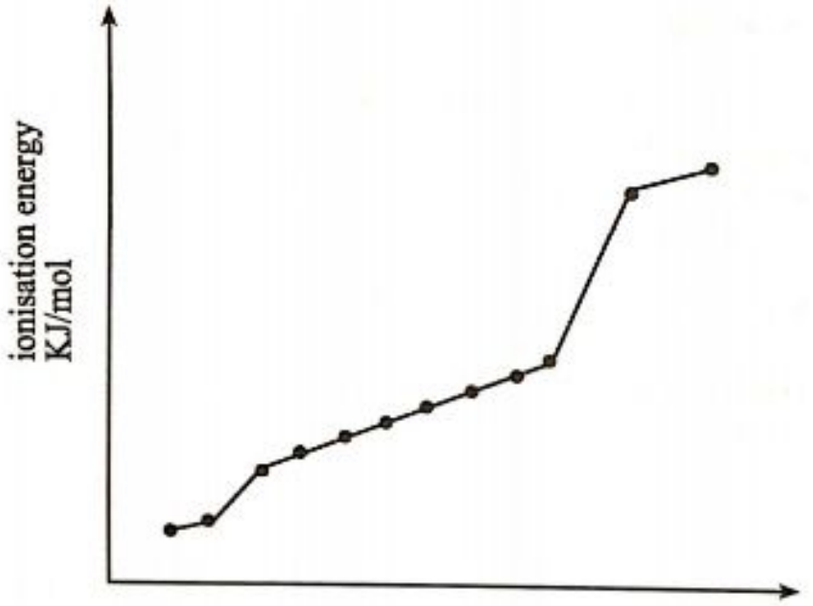


Fig. 3.1

(i) Define the term *first ionisation energy*.

(ii) Write an equation to illustrate the second ionisation of magnesium.

(iii) Explain how **Fig. 3.1** shows that there are three electron shells in magnesium.

[4]

(b) Aluminium exists as a mixture of three isotopes. Information about two of its isotopes is shown in the mass spectrum in **Fig. 3.2.**

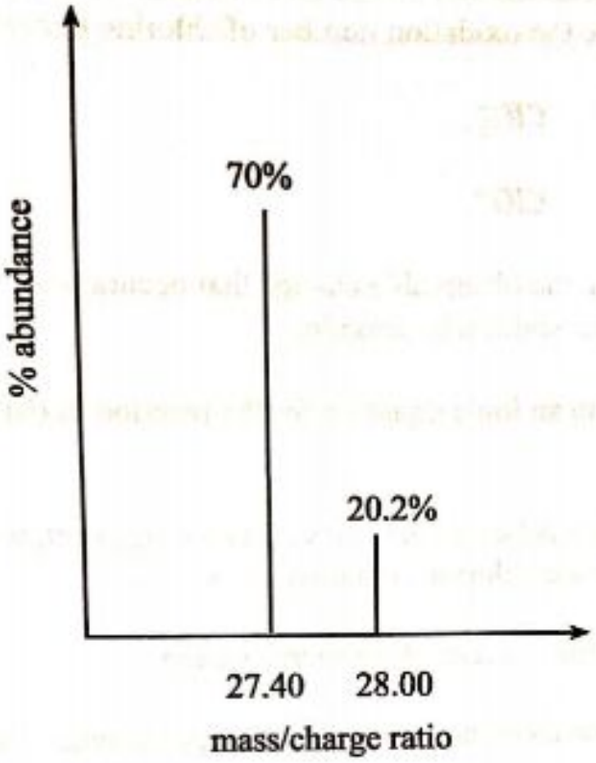


Fig. 3.2

Calculate the relative isotopic mass of the third isotope.

[5]

(c) Explain why

(i) aluminium oxide is used as an insulator in spark plugs,

(ii) the first ionisation energy of potassium is lower than that of argon,

(iii) $SiCl_4$ is a liquid at room temperature whereas PCl_5 is a solid.

[6]

[Total:15]

Section B

*Answer **one** question from this section.*

4 **(a)** **(i)** State the oxidation number of chlorine in

1. ClO_3^-,

2. ClO^-.

(ii) State the observable change that occurs when chlorine is added to hot sodium hydroxide.

(iii) Write an ionic equation for the reaction in **(ii)**.

[5]

(b) When $KClO_3$ is heated just above its melting point, it disproportionates to produce two chlorine containing products.

(i) Define the term *disproportionation*.

(ii) Write an equation for the disproportionation of $KClO_3$.

[3]

(c) A 0.598 g sample of a metal carbonate, MCO_3 decomposed to give the metal oxide and 0.222 g CO_2.

Deduce the identity of the carbonate.

[7]

[Total:15]

5 **(a)** A group (IV) tetrachloride, XCl_4, is simple molecular and can be hydrolysed in water to form XO_2.

(i) State the shape and the bond angles of the tetrachloride.

(ii) Write a balanced equation for the hydrolysis of the tetrachloride.

(iii) Explain why CCl_4, another group (IV) tetrachloride, does not hydrolyse in water.

[5]

(b) Explain why

(i) CCl_4 does not decompose when heated but $PbCl_4$ readily decomposes,

(ii) phosphorus burns under mild temperatures but nitrogen does not,

(iii) nitrogen forms NO_2 as its stable oxide but phosphorus forms P_4O_{10},

(iv) halogens are not directly soluble in water but are more readily soluble in hexane,

(v) a brown solution is formed when chlorine is added to potassium iodide solution.

[10]

[Total:15]

Section C

Answer any two questions from this section.

6 **(a)** The boiling points of propan-1-ol and pentan-3-ol are 98 °C and 124 °C respectively.

(i) Explain the difference in the boiling points

(ii) State, with reasons, the alcohol that is more acidic.

(iii) Give a two step test to distinguish between propan-1-ol and pentan-3-ol.

[6]

(b) The oxidation half equation for pentan-3-ol is:

$$CH_3CH_2CH(OH)CH_2CH_3 \longrightarrow CH_3CH_2COCH_2CH_3 + 2e^- + 2H^+$$

Deduce a balanced equation for the oxidation of pentan-3-ol by acidified potassium dichromate (IV).

[2]

(c) Alcohols of the general formula shown in **Fig. 6.1**, undergo a four step triiodo methane reaction.

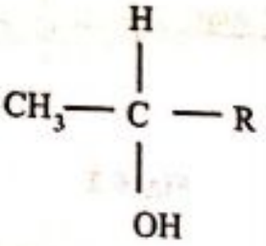
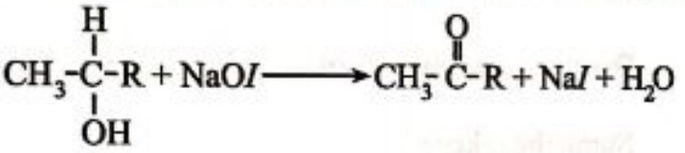
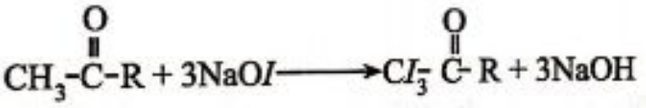


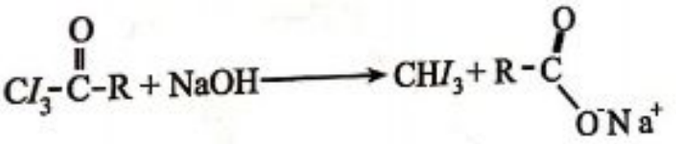
Fig. 6.1

The steps are:

step I $2NaOH + I_2 \longrightarrow NaOI + NaI + H_2O$

step II 

step III 

step IV 

(i) State the observation made in the triiodomethane test.

(ii) Name the type of reaction in step II.

(iii) Deduce a balanced equation for the overall triiodomethane reaction of the alcohol, $CH_3CH(OH)CH_2CH_3$. [4]

(d) Propan-2-ol undergoes the reactions shown in **Fig. 6.2.**

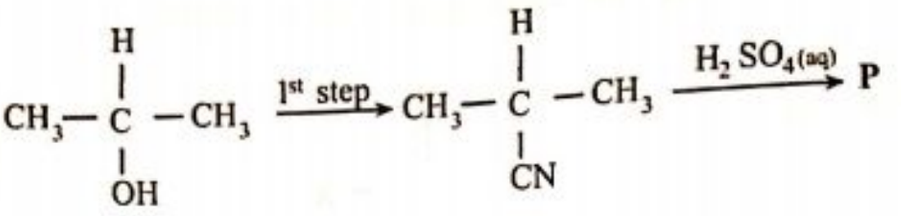


Fig. 6.2

(ii) State the reagents and conditions for the 1st step.

(ii) Draw the structure of the organic product **P**.

[3]

[Total:15]

7 (a) An alkene of molecular formula C_6H_{12} was found to be chiral.

(i) Draw the displayed formula of the alkene.

(ii) Name the alkene.

(iii) Draw a diagram to show the isomerism of the alkene.

[4]

(b) An organic compound, **D**, reacts with aqueous sodium hydroxide under different conditions to form compounds **E** and **F** as shown in **Fig. 7.1**.

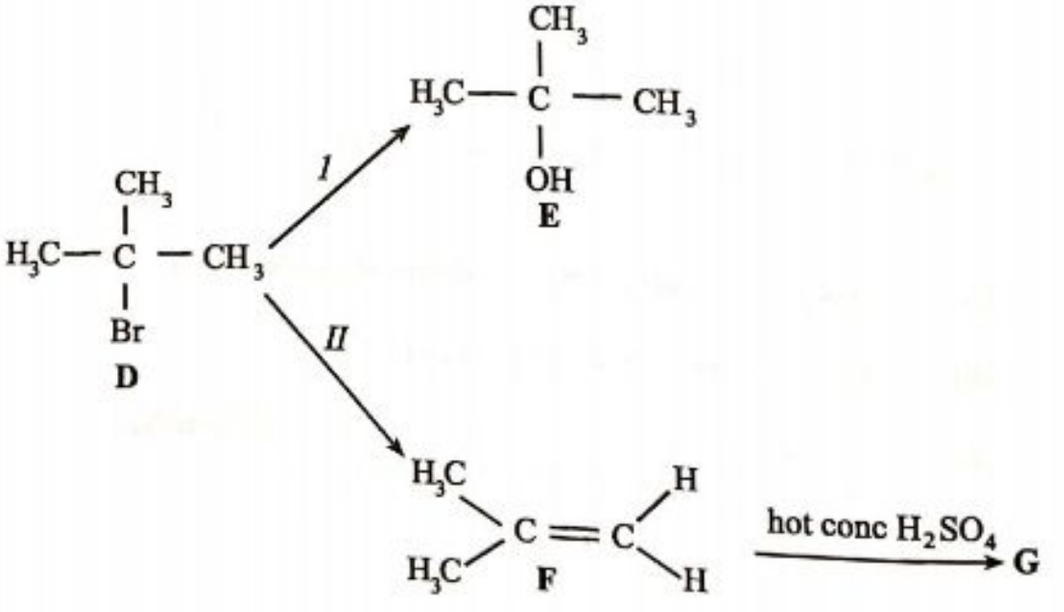


Fig. 7.1

(ii) Give the name and conditions for

1. reaction *I*,
2. reaction *II*.

(ii) Describe the mechanism of reaction *I*.

(iii) Suggest the role of aqueous sodium hydroxide in each reaction.

[8]

(c) Compound **F**, undergoes further reaction with hot concentrated H_2SO_4 to form **G**.

(i) Name the type of reaction.

(iii) Draw the structure of **G**.

(iii) Name the other product formed in the reaction.

[3]
[Total:15]

8 (a) A reaction scheme involving benzene is shown.

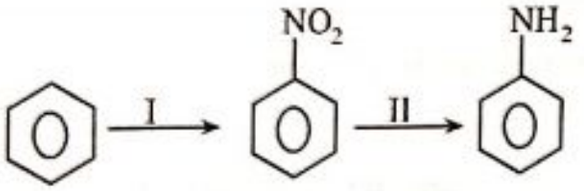


Fig. 8.1

(i) State the reagants and conditions for reaction I.

(ii) State the type of reaction in step II.

(iv) Compare the reactivities of the three compounds shown in **Fig. 8.1** when reacted with $Br_{2(aq)}$. [5]

(b) The K_a values of three organic compounds are shown in **Table 8.1**.

Table 8.1

acid	K_a
CH_3CO_2H	1.6×10^{-5}
CH_2ClCO_2H	1.3×10^{-3}
$CH_2Cl_2CO_2H$	5.0×10^{-2}

Explain the trend in the acid strength of the three compounds. [3]

(c) **Fig. 8.2** shows how ethylbenzene reacts with Bromine.

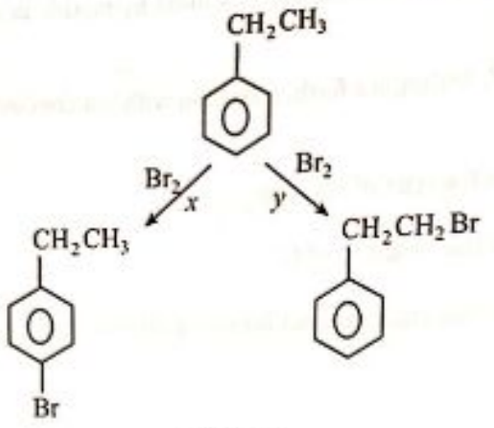


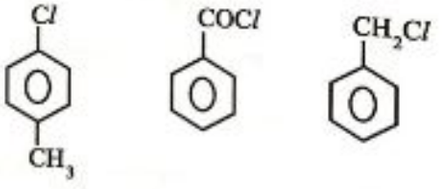
Fig. 8.2

(i) Name reaction *x*.

(ii) State the condition for reaction *y*.

[2]

(d) **Fig. 8.3** shows the structures of three benzene derivatives, **X**, **Y** and **Z**.



X **Y** **Z**

Fig. 8.3.

State and explain the trend in the ease of hydrolysis of **X**, **Y** and **Z**.

[5]

[Total:15]

Section D

Answer **one** question from this section.

9 **(a)** State, with reasons, which of the two ions, Mn^{2+} and Fe^{2+}, is more stable. [2]

(b) Explain why

(i) iron (III) chloride forms an acidic solution when dissolved in water,

(iii) neither $[Mn(H_2O)_6]^{7+}$ nor $[Cr(H_2O)_6]^{6+}$ exists in aqueous solution.

[6]

(c) The partition coefficient of iodine between ether and water is 4.

(i) Explain the term *partition coefficient*.

(ii) State any **one** condition that affects the magnitude of a partition coefficient.

(iii) Calculate the

1. mass of iodine that can be extracted by shaking 100 cm^3 of ether with 100 cm^3 of an aqueous solution containing 8 g of iodine,

2. total mass of iodine that can be extracted from the same 100 cm^3 of aqueous solution containing 8 g of iodine by two successive extractions of 50 cm^3 of ether.

(iv) Comment on the values in **(iii)**. [7]

[Total:15]

10 **(a)** Describe and explain

(i) the environmental effects of emitting sulphur dioxide into the atmosphere,

(ii) how sulphur dioxide is removed from a gaseous industrial effluent using flue gas desulphurisation,

(iii) any **two** disadvantages of land filling as a method of waste disposal. [8]

(b) Explain why

(i) waste sorting is recommended before disposal,

(ii) soil near a highway has higher levels of lead than soils in other areas.

[4]

(c) Human hair is an example of a nanostructure.

(i) Explain the term *nanostructure*.

(ii) Describe and explain the advantages of using catalysts based on nanostructures than those based on bulk material catalysts.

[3]

[Total:15]

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

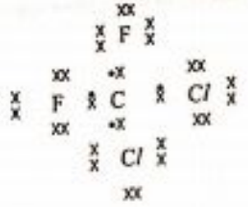
SUGGESTED ANSWERS AND SOLUTIONS

NOVEMBER 2019

6031/3

CHEMISTRY

1 (a) (i)



(ii) Four bonded pairs, no lone pair;
Tetrahedral;

(b) (i) Mass of carbon = $\frac{0.176}{44} \times 12 = 0.048$ g;

Mass of hydrogen = $\frac{0.072}{18} \times 2 = 0.008$ g ;

Mass of oxygen = 0.120 – (0.048 + 0.008)

= 0.064 g;

C	H	O
$\frac{0.048}{12}$	$\frac{0.008}{1}$	$\frac{0.064}{16}$
1	2	1;

Empirical formula is CH_2O;

$M_r = \frac{mRT}{pV} = \frac{0.148 \times 8.31 \times 333}{1.01 \times 10^5 \times 67.7 \times 10^{-6}}$;

= 59.89

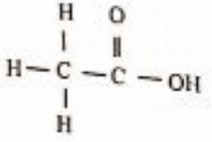
= 60;

$(CH_2O)n = 60$

$n = 2$

Molecular formula is $C_2H_4O_2$;

(ii)



(c) (i) Neutralises excess stomach acids;

(ii) $Mg(OH)_{2(aq)} + 2HCl_{(aq)} \longrightarrow MgCl_{2(aq)} + 2H_2O_{(l)}$;

$n(HCl) = \frac{\frac{0.15 \times 28.33}{1.201}}{4.25} \times 10^{-3}$ moles;

$n(Mg(OH)_2) = \frac{1}{2} \times \frac{0.15 \times 28.30}{100} / 2.21 \times 10^{-3}$ moles

$mMg(OH)_2 = 2.21 \times 10^{-3} \times 58.3$

$= 0.129$ g

$\%\ Mg(OH)_2 = \frac{0.129}{0.5} \times 100 / 25.8\%$;

2 (a) (i) regulates blood pH;

(ii) $H^+ + HCO_3^- \longrightarrow H_2CO_3$;

$OH^- + H_2CO_3 \longrightarrow HCO_3^- + H_2O$;

(iii) $pH = pKa + \log\left(\frac{[NaHCO_3]}{[H_2CO_3]}\right)$

$5.94 = 6.33 + \log\left(\frac{x}{0.5}\right)$;

$[NaHCO_3] = 0.2035\ mol/dm^3$;

$n(NaHCO_3) = C.V = 0.2035 \times 250 \times 10^{-3}$;

$= 0.050875$ moles;

$m(NaHCO_3) = n.M = 0.050875 \times 84$

$= 4.27$ g;

(b) (i) $K_c = \frac{[CH_3CH(OCH_3)_2][H_2O]}{[CH_3CHO][CH_3OH]^2}$;

Initial	0.131	0.129	0.0785	0.0418
Transformed	x	$2x$	x	x
Equilibrium	$0.131-x$	$0.129-2x$	$0.0785+x$	$0.0418+x$
	$0.131-0.0326$	0.0638	$0.0785+0.0326$	$0.0418+0.0326$
	$=0.0984$		$=0.1111$	$=0.0744$

$0.129 - 2x = 0.0638$

$\therefore x = 0.0326$

Correct value of x;

All correct equilibrium moles;

$$K_c = \frac{\left(\frac{0.1111}{0.025}\right)\left(\frac{0.0744}{0.025}\right)}{\left(\frac{0.0986}{0.025}\right)\left(\frac{0.0638}{0.025}\right)^2};$$

$$\frac{(\text{mol.dm}^{-3})^2}{(\text{mol.mol}^{-1})^3};$$

$= \quad 0.516 \ \text{dm}^3\text{mol}^{-1};$

(ii) Add concentrated H_2SO_4 a drying agent/removes water; thereby shifting the equilibrium position to the right/favouring the forward reaction; by changing initial composition of the mixture (increase moles of one of the reactants or both).

3 (a) (i) Enthalpy change when one mole of electrons is removed from a mole of gaseous atoms to form a mole of unipositive ions;

(ii) $Mg^+(g) \longrightarrow Mg^{2+}_{(g)} + e^-$

(iii) There is a jump in energy between the 2nd and 3rd electron, between 10th and 11th electron proving the 3 shells;

(b) $100 - (70 + 20.2) = 9.8\%$;

Let the relative isotopic mass of the third isotope by y;

$$\frac{27.40 \times 70 + 28.00 \times 20.2 + 9.8\,y = A_r\,(Al);}{100}$$

$$\frac{1\,918 + 565.6 + 9.8\,y}{100} = 26.982$$

$$2\,483.6 + 9.8\,y = 2\,698.2$$

$$y = \frac{2\,698.2 - 2\,483.6}{9.8}$$

$= \quad 21.98;$

(c)

(i) Al_2O_3 has a high melting point;
It does not conduct electricity in solid state, ions are not free to move;

(ii) K has a larger atomic radius electron in outer shell less firmly held;
outer most electron screened from nucleus by inner shells;

(iii) PCl_5 has more electrons per molecule;
Hence greater van der Waals forces;

4 (a) (i) 1. +5;

2. +1;

(ii) yellowish/green colour of Cl_2 disappears;

$3Cl_2 + 6OH^- \longrightarrow 5Cl^- + ClO_3^- + 3H_2O$;

(b) (i) Simultaneous oxidation and reduction of the same species;

(ii) $4KClO_3 \longrightarrow 3KClO_4 + KCl$;

(c) $MCO_{3(s)} \xrightarrow{heat} MO_{(s)} + CO_{2(g)}$

Moles of $CO_2 = \frac{0.222\ g}{44}$ / 5.045×10^{-3} moles;

1 : 1 rxn ratio - moles of $MCO_3 = 5.045 \times 10^{-3}$;

$\frac{m}{M_r} = 5.045 \times 10^{-3} \times M_r$;

$\frac{0.598}{5.045 \times 10^{-3}} = 5.045 \times 10^{-3} \times (Y + 12 + 48)$;

$\frac{0.598}{5.045 \times 10^{-3}} = Y + 60$;

Y = 58.5

$MCO_3 \Rightarrow NiCO_3$

5 (a) (i) tetrahedral;

109.5°;

(ii) $XCl_4 + 2H_2O \longrightarrow XO_2 + 4HCl$;

(iii) X has vacant 'd'-orbitals;

which can allow the lone pair of O_2 to bond datively with X;
Ln CCl_4 the C – atom does not have accessible 'd'-orbitals to bond with water molecules;

(b) (i) C-Cl bond energy in C-Cl_4 is very short/very strong does not break easily; small size of carbon atom;

Pb-Cl bond energy weak/long due to large size of Pb atom;

(ii) N_2 is unreactive;

short triple bonds, high bond energy;
bonds in phosphorus are longer, single and weaker;

(iii) Large P atoms with vacant 'd'-orbitals;

N atoms are small, no vacant 'd'-orbitals cannot expand its orbit;

(iv) Halogens have Vander Waals forces hence dissolve in hexane which has similar interactions but water has hydrogen bonds.

(v) Chlorine oxides iodine iodide ions to iodine.

6 (a) (i) Stronger van der Waals forces in pentan-3-ol due to more electrons per molecule/larger size/AW;

(ii) Propanol is more acidic/AW;

There are two alkyl groups in pentan-3-ol which strength the O-H bond compared to only one in propan-1-ol/AW;

(iii)
- add $K_2Cr_2O_7$ and $H_2SO_{4(aq)}$ then heat;
- to the product add 2, 4 DNPH;
- only pentan-3-ol gives a yellow/orange ppt;

(b) $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$

$3(CH_3CH_2CH(OH)CH_2CH_3 \rightleftharpoons CH_3CH_2COCH_2CH_3 + 2H^+ + 2e^-)$;

$3CH_3CH_2CH(OH)CH_2CH_3 + Cr_2O_7^{2-} + 8H^+ \longrightarrow 2Cr^{3+} + 7H_2O +$
$CH_3CH_2COCH_2CH_3$;

(c) (i) Yellow crystals (of CHI_3);

(ii) Oxidation;

(iii) $2NaOH + I_2 \longrightarrow NaOI + NaI + 2H_2O$

$CH_3CH(OH)R + NaOI \longrightarrow CH_3COR + NaI + H_2O$

$CH_3COR + 3NaOI \longrightarrow CI_3COR + 3NaOH$

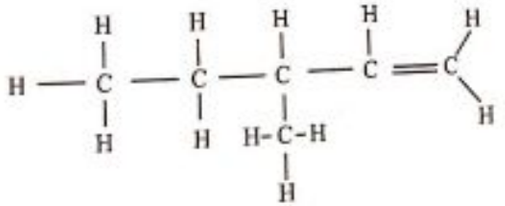
$CI_3COR + NaOH \longrightarrow CHI_3 + RCOONa$

$6NaOH + 4I_2 + CH_3CH(OH)R \longrightarrow CHI_3 + RCOONa + 5NaI + 5H_2O$

(d) (i) KCN, in ethanol, reflux;

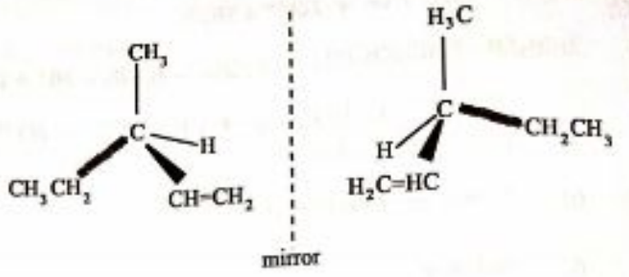
(ii) $CH_3CH(CH_3)COOH$;

7 (a) (i)



(ii) 3-methylpent-1-ene;

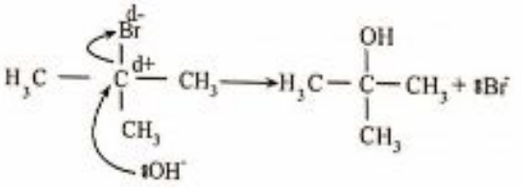
(iii)

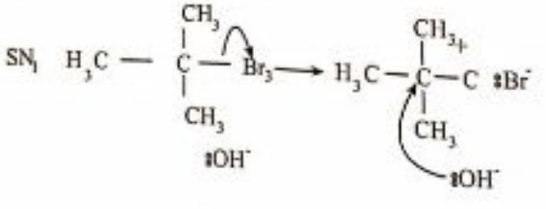


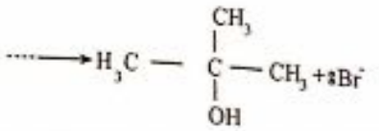
(b) (i) 1. Nucleophilic substitution; KOH/$NaOH_{(aq)}$, reflux;

2. Elimination; ethanol in NaOH/KOH, reflux;

(ii)







(iii) Reaction 1: acting as a nucleophile
Reaction II: acting as a base

(c) (i) oxidation;

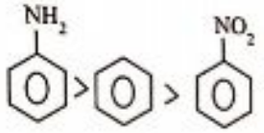
(ii) $H_3CC(CH_3)O$

(iii) CO_2/ H_2O

5 (a) (i) concHNO$_3$, concH$_2$SO$_4$
and 50 °C ≤ T ≤ 60 °C;

(ii) Reduction;

(iii) Reactivity decreases in the order;



;

lone pair of electrons on the N atom in NH_2 partially overlaps/delocalises into the ring increasing the charge density;

the electronegative oxygen atoms in nitrobenzene withdraw electrons from ring reducing the charge density;

(b) The more the chlorine atoms, the stronger the acid;
due to the electron withdrawing effect/ negative inductive effect of *Cl*;

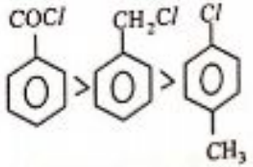
(which stabilises the anion/RCO_2^- OR which spreads the negative charge more OR which weakens the O-H bond OR which facilitates the H^+ donation OR which makes the equilibrium

$RCO_2H \rightleftharpoons RCO_2^-$ lie further to the right)

(c) (i) electrophilic substitution;

(ii) UV light;

(d)



Ease of hydrolysis decreases in the shown order;

Y has a highly $\delta+$ carbon atom bonded to two highly electronegative atoms;

Z has one electron withdrawing group)

In X, Lone pair of electrons on the Cl atom delocalises over the benzene ring which makes the C-Cl bond difficult to break/ C-Cl bond has a partial double bond character;

OR delocalised electrons on the ring repel the OH^-

9 (a) Mn^{2+} is more stable;

has a half filled 3d orbital;

(b) (i) high charge density on Fe^{3+},
polarises the water ligand; thereby liberating $H^+_{(aq)}$

(ii) ions have extremely high charge densities;
polarises water ligands;
compounds dissociates forming oxyanions;

(c) (i) An equilibrium constant showing how a solute which is soluble in two immiscible solvents distributes itself between them /AW

$$K_d = \frac{[X]\text{solvent A}}{[X]\text{solvent B}}$$

(ii) Temperature;

(iii) I. Let x be mass of I_2

$$\frac{x}{100} \times \frac{100}{8-x} = 4$$

$x = 6.49$ g;

2. Successive extractions

1st extraction

$$\frac{x_1}{50} \times \frac{100}{8-x} = 4$$

$x_1 = 5.33\ g$;

Second extraction : mass I_2 remaining = (8 – 5.33) G

= 2.67 g

$\frac{x_2}{50} \times \frac{100}{2.67 - x_2}$

$x_2 = 1.78$ g;

Total mass $= 5{,}33 + 1{,}78$

$=$ 7.11 g

(iv) Comment:

More efficient to use successive small portions of solvent 7.11 g > 6.49 g

10 (a) (i) SO_2 dissolves in water vapour forming acid rain;

acid rain corrodes structures;

SO_2 turns lead based paint to black causing buildings to discolour;

(ii) gas reacted with a carbonate;

$SO_2 + CaCO_3 \longrightarrow CaSO_{3(s)} + CO_{2(g)}$

$CaO + SO_2 \longrightarrow CaSO_3$;

$2CaSO_3 + O_2 + 4H_2O \longrightarrow 2CaSO_4.4H_2O$;

(iii) leachate produced contaminates water bodies;

the CH_4 gas produced is toxic, explosive and cause fire outbreaks

(b) (i) enables recovery of useful materials;
minimises material to be disposed;
extract value;
store recyclable material for reuse;
reduces landfill space for final disposal;
reduces pollution;

(ii) - unburnt leaded petrol from exhaust fumes
- headed petrol leaking from vehicles

(c) (i) Structures with at least one dimension roughly between 1 and 100 nanometers/ structures sized between 1 to 100 nm

(ii) high surface to volume ratio gives the extra chemical reactivity;

less of the catalyst is used;

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Ordinary Level

CHEMISTRY 6031/4

Paper 4 Practical Test 2 hours 30 minutes

NOVEMBER 2019

Detailed Identities of Chemicals Required

The identities of the chemicals with FA code numbers are as follows:

1 **FA1** is 59.8 gdm^{-3} mixture of $NaOH_{(aq)}$ and $Na_2SO_{4(aq)}$ prepared by dissolving 35.9 g NaOH and 23.9 g Na_2SO_4 in 1000 cm^3.

2 **FA2** is 4.9 gdm^{-3} H_2SO_4

3 **FA4** is a mixture of 0.2 $moldm^{-3}$ $Al(NO_3)_3$ and 0.2 $moldm^{-3}$ $Pb(NO_3)_2$ [mix equal quantities]

4 **FA5** is 0.2 $moldm^{-3}$ $NaNO_3$

5 **FA6** is 0.2 $moldm^{-3}$ Na_2SO_3,

6 **FA7** is 0.2 $moldm^{-3}$ $NaNO_2$,

7 **FA8** is 0.2 $moldm^{-3}$ Na_2CO_3.

1 **FA1** is an aqueous alkaline pesticide containing 59.80 g/dm³ of sodium hydroxide and sodium sulphate.
FA2 contains 4.90 g/dm³ sulphuric acid.

You are required to determine the mass of sodium hydroxide and sodium sulphate in the pesticide.

(a) Place between 22.30 cm³ and 22.60 cm³ of **FA1** into a 250.00 cm³ volmetric flask using a burette.

(i) Record the volumes in **Table 1.1**.

Table 1. 1

Final burette reading /cm³	
Initial burette reading /cm³	
Volume of **FA1**/cm³	

[2]

(ii) Dilute the **FA1** to the mark with distilled water then label it **FA3**.

Pipette 25.00 cm³ of **FA3** into a conical flask

Add 3 drops of phenolphthalein.

Titrate **FA3** against **FA2** and record the results in **Table 1.2**.

Repeat the titration as many times as necessary to obtain accurate results.

Table 1.2

Final burette reading /cm³					
Initial burette reading /cm³					
Volume of **FA2** used/cm³					
Best titration (√)					

[15]

Summary:

25.00 cm³ of **FA3** required _____ cm³ of **FA2**. [1]

(b) Calculate the

(i) concentration in moldm^3, of H_2SO_4 in **FA2**.
[A_r: H: 1, S: 32, O: 16]

[1]

(ii) number of moles of H_2SO_4 in the titre obtained.

[1]

(c) Write a balanced chemical equation for the reaction.

[1]

(d) Calculate the

(i) number of moles of NaOH in the 25.00 cm^3 of **FA3**.

[1]

(ii) mass of NaOH in 250.00 cm^3 of **FA3**.

[1]

(iii) mass of Na_2SO_4 in the diluted volume of **FA1**.
[A_r: Na: 23, S: 32, O: 16, H: 1]

[2]
[Total: 24 marks]

2 **FA4** is an aqueous solution containing **two** cations and **one** anion.

Carry out the tests described in the table to identify the ions present in **FA4**.

In all the tests, reagents should be added gradually until no further change occurs, with shaking after each addition.

Observations should include:

(i) descriptions of colour changes and precipitates

(ii) the names of gases evolved and details of the test used to identify them

You should indicate clearly at what stage in the test a change occurs, writing any deductions you make alongside the observations on which they are based.

N.B [No additional or confirmatory tests for ions present should be attempted.]

test	observations (10)	deductions (5)
(a) To a portion of **FA4**, add $NaOH_{(aq)}$ until excess add aluminium foil and warm gently		
(b) To a portion of **FA4**, add $NH_{3(aq)}$ until excess		

Test	Observations (10)	Deductions (5)
(c) To a portion of **FA4**, add $Na_2CO_{3(aq)}$		
(d) To a portion of **FA4**, add $KI_{(aq)}$		
(e) To a portion of **FA4**, add $HNO_{3(aq)}$ followed by $AgNO_{3(aq)}$		

[13]

Summary

Cations in **FA4** _____ and _____ [2]

Anion in **FA4** _____ [1]

[Total: 16 marks]

Assessment of Planning Skills

Design and carry out your plan.

3 **FA5, FA6, FA7 and FA8** are aqueous solutions, which contain Na_2CO_3; Na_2SO_3, $NaNO_2$ and $NaNO_3$ but not necessarily in that order.

You are required to design and **carry out** experiments to identify the solutions.

(a) Describe how

(i) the aqueous solutions can be identified using $NaOH_{(aq)}$ and any of the materials listed below,

aluminum foil
test tube
burner
test tube holder
aqueous silver nitrate
red litmus paper

(ii) sulphuric acid can be used to further confirm the identities of the solutions.

(b) **Carry out** the tests described in (a) and record the observations and identify the solutions

ZIMBABWE SCHOOL EXAMINATIONS COUNCIL

General Certificate of Education Advanced Level

SUGGESTED ANSWERS AND SOLUTIONS

NOVEMBER 2019

CHEMISTRY

6031/4

Table 1.1

1 (a) (i) Dilution of FA1

Correct subtraction

Recorded volume of **FA1** in the range 22.35 cm^3 to 22.55 cm^3
(all volumes are recorded to 2 decimal places)

(ii) Table 1.2

Correct subtraction and not more than 1 zero start in all experiments;
At least two titres within 0.10 cm^3;
Burette readings recorded to 2 decimal places, ticked
used results and working shown for the average and completing the summary rounding up or down to 0.05.

(b) (i) $\frac{4.9}{M_r(H_2SO_4)}$ / $\frac{4.9}{98}$

(ii) $\frac{\text{Titre}}{1\,000} \times$ ans b(i)

(c) $H_2SO_{4(aq)} + 2NaOH_{(aq)} \longrightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$ ® wrong state symbols

(d) (i) ans b(ii) × 2

(ii) ans d(i) × $M_r(NaOH) \times \frac{250}{25}$

(iii) $\frac{\textit{Diluted FA1 Volume}}{1000} \times 59.8 -$ ans d(ii)

2

TEST	OBSERVATION	DEDUCTIONS
(a)	White ppt; soluble in excess A gas which turns damp red litmus blue;	$Pb^{2+}/Al^{3+}/Mg^{2+}/Zn^{2+}$; $Pb^{2+}/Al^{3+}/Zn^{2+}$; NO_3^-/NO_2^-.
(b)	White ppt; Insoluble in excess;	Al^{3+} / Pb^{2+}/Zn^{2+} Al^{3+}/Pb^{2+}
(c)	White ppt; and effervescence;	Pb^{2+}/Al^{3+}
(d)	Yellow ppt;	Pb^{2+};
(e)	No observable change; No observable Change	Absence of CO_3^{2-}, SO_3^{2-}; NO_2^- Absence of halide ions / Cl^-, Br^-, I^- Halide ions/; Cl^-, Br^-, I^-/

Summary

Cations in **FA4:** Al^{3+} and Pb^{2+};

Anion in **FA4** NO_3^-;

3 (a) (i)
- To portions of **FA5** to **FA8** add sodium hydroxide, aluminium foil and heat gently.
- Portions which produced gas bubbles with pungent smell which turns damp red litmus paper blue identifies $NaNO_3$; and $NaNO_2$.
- further confirmation is needed for all the four portions

(ii) **Step 1**

- Add Sulphuric acid to those portions that produced pungent smelling gas which turn red damp litmus blue and observe.
- a portion which produced brown gas confirms presence of $NaNO_2$.
- a portion where there was no observable change confirms presence of $NaNO_3$

Step 2
- add sulphuric acid to other two portions
- a portion which produced a pungent smelling gas confirms presence of Na_2SO_3
- a portion which produced effervescence / odourless gas confirms presence of Na_2CO_3

	OBSERVATIONS			
STEP	**FA5**	**FA6**	**FA7**	**FA8**
1. Add $NaOH_{(aq)}$, aluminium foil and warm gently.	Bubbles; pungent smelling gas turns damp red litmus blue	No observable change	Bubbles; pungent smelling gas turns damp red litmus blue	No observable change
2. Add $H_2SO_{4(aq)}$	No observable change	Bubbles; pungent smelling gas	Bubbles, brown gas	effervescence
Confirmation	$NaNO_3$	Na_2SO_3	$NaNO_2$	Na_2CO_3