**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF SCIENCE AND TECHNOLOGY EDUCATION**

**DEPARTMENT OF SCIENCE, MATHEMATICS AND TECHNOLOGY EDUCATION**

# ORGANIC CHEMISTRY (PST2042)

**Main Examination Paper**

**NOVEMBER 2024**

**This Examination Paper consists of 3 pages**

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: Graph Paper

Internal Examiner: Ms I Mpofu

External Examiner: Dr S.J. Mpofu

## INSTRUCTIONS

1. Section A: Answer two (2) questions.
2. Section B: Answer any three (3) questions.
3. Each question carries 20 marks
4. Use curved arrows to show mechanisms or reaction steps.

## MARK ALLOCATION

| QUESTION | MARKS |
|---|---|
| 1 | 20 |
| 2 | 20 |
| 3 | 20 |
| 4 | 20 |
| 5 | 20 |
| 6 | 20 |

**SECTION A: Answer two questions. [40]**

**Question 1**

a) The table gives the boiling points of three alkanes.

| Compound | Molar mass | Bp /K |
|---|---|---|
| Methane | 16 | 111.0 |
| Pentane | 72 | 309.1 |
| 2,2-dimethylpropane | 72 | 282.5 |

Explain the difference in the boiling points of

(i) methane and pentane. (ii) pentane and 2,2-dimethylpropane. [3+3]

b) Distinguish clearly between: (i) Stereo isomers and structural isomers. (ii) optical isomers and geometric isomers. [3+3]

c) Draw and name all the possible isomers for the molecule $C_3H_5Br$. [8]

**Question 2**

a) (i) Name the structural isomer of propanone. (ii) Describe how you would distinguish between this isomer and propanone. [1+3]

b) Outline a method for the preparation of propanone from propene. [4]

c) Give a reagent or set of reagents which will convert ethanal into (i) $CH_3CO_2H$. (ii) $CHI_3 + HCO_2Na$. (iii) $CH_3CH(OH)_2$. [2x3]

d) Draw the structure of the product obtained when ethanal reacts with
(i) 2,4-dinitrophenylhydrazine. (ii) hydrogen cyanide. (iii) $LiAlH_4$. [2x3]

**SECTION B: Answer any three questions. [60]**

**Question 3**

a) Write the structural and molecular formula of
(i) 2.4.5-trimethylheptane [4]
(ii) 2-chloro-3-methylhexane. [4]

b) When a solution of chlorine in hot ethanoic acid is irradiated with ultraviolet light, 2-chloroethanoic acid is formed.
(i) Write the structural formula of ethanoic acid and chloroethanoic acid. [2]
(ii) Show by means of equations the steps in the reaction of ethanoic acid and chlorine to form 2-chloroethanoic acid. [10]

**Question 4**

a) Describe, using curly arrows the mechanism for the formation of benzene sulphonic acid from benzene and fuming sulphuric acid. [10]

b) Explain the reason for the difference in the reactivity towards electrophiles of benzene and methylbenzene. [4]

c) Compare and contrast the reaction of But-1-yne with hydrogen bromide in the presence and absence of peroxide. [6]

**Question 5**

a) Compounds A and B are colourless liquids with the formula $C_4H_{10}O$. A reacts with sodium, with the release of hydrogen gas. A also reacts with concentrated hydrogen iodide to form compound C, $C_4H_9I$. Compound B does not react with sodium, but reacts with concentrated hydrogen iodide to form compound D, $C_2H_5I$.
(i) Identify the compounds A and B. [2]
(ii) Write equations for all the reactions that occur. [6]

c) (i) Give the structural formulae and names of a primary, a secondary and a tertiary alcohol. [6]

(ii) Explain how you could distinguish between them. [6]

**Question 6**

The following scheme outlines a series of reactions involving compounds A to E.

$C_5H_{10}O_2$ (A) → $C_5H_{10}O$ (B) → $C_5H_{12}O$ (C) → $C_5H_{10}$ (D) → $C_5H_{10}Br_2$ (E)

Compound A contains a straight chain of carbons and turns blue litmus red.

a) For each compound A to E: Draw the structure; clearly label the functional group and name the compound. [15]

b) Describe and explain how the experimental conditions are important in determining the nature of the products of an organic reaction by reference to the reaction of 3-bromopentane with potassium hydroxide. [5]

# Ptable

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 H 1.00794 | Atomic Sym Weight | C Solid | | | | Metalloids | Nonmetals | | | | | | | | | | 2 He 4.00260 |
| | | | Hg Liquid | | | | | Other nonmetals | | Halogens | | Noble gases | | | | | | |
| 2 | 3 Li 6.941 | 4 Be 9.01218 | H Gas | | | | Metals | | | | | | 5 B 10.811 | 6 C 12.0107 | 7 N 14.0067 | 8 O 15.9994 | 9 F 18.9984 | 10 Ne 20.1797 |
| 3 | 11 Na 22.9897 | 12 Mg 24.305 | Rf Unknown | | | Alkali metals | Alkaline earth metals | Lanthanoids | | Transition metals | | Post-transition metals | 13 Al 26.9815 | 14 Si 28.0855 | 15 P 30.9737 | 16 S 32.065 | 17 Cl 35.453 | 18 Ar 39.948 |
| | | | | | | | | Actinoids | | | | | | | | | | |
| 4 | 19 K 39.0983 | 20 Ca 40.078 | 21 Sc 44.9559 | 22 Ti 47.867 | 23 V 50.9415 | 24 Cr 51.9961 | 25 Mn 54.9380 | 26 Fe 55.845 | 27 Co 58.9331 | 28 Ni 58.6934 | 29 Cu 63.546 | 30 Zn 65.38 | 31 Ga 69.723 | 32 Ge 72.63 | 33 As 74.9216 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.798 |
| 5 | 37 Rb 85.4678 | 38 Sr 87.62 | 39 Y 88.9058 | 40 Zr 91.224 | 41 Nb 92.9063 | 42 Mo 95.96 | 43 Tc (98) | 44 Ru 101.07 | 45 Rh 102.905 | 46 Pd 106.42 | 47 Ag 107.868 | 48 Cd 112.411 | 49 In 114.818 | 50 Sn 118.71 | 51 Sb 121.76 | 52 Te 127.6 | 53 I 126.904 | 54 Xe 131.293 |
| 6 | 55 Cs 132.905 | 56 Ba 137.327 | 57–71 | 72 Hf 178.49 | 73 Ta 180.947 | 74 W 183.84 | 75 Re 186.207 | 76 Os 190.23 | 77 Ir 192.217 | 78 Pt 195.084 | 79 Au 196.966 | 80 Hg 200.59 | 81 Tl 204.383 | 82 Pb 207.2 | 83 Bi 208.980 | 84 Po (209) | 85 At (210) | 86 Rn (222) |
| 7 | 87 Fr (223) | 88 Ra (226) | 89–103 | 104 Rf (267) | 105 Db (268) | 106 Sg (271) | 107 Bh (272) | 108 Hs (270) | 109 Mt (276) | 110 Ds (281) | 111 Rg (280) | 112 Cn (285) | 113 Uut (284) | 114 Fl (289) | 115 Uup (288) | 116 Lv (293) | 117 Uus (294) | 118 Uuo (294) |

For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.



| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 La 138.905 | 58 Ce 140.116 | 59 Pr 140.907 | 60 Nd 144.242 | 61 Pm (145) | 62 Sm 150.36 | 63 Eu 151.964 | 64 Gd 157.25 | 65 Tb 158.925 | 66 Dy 162.5 | 67 Ho 164.930 | 68 Er 167.259 | 69 Tm 168.934 | 70 Yb 173.054 | 71 Lu 174.966 |
| 89 Ac (227) | 90 Th 232.038 | 91 Pa 231.035 | 92 U 238.028 | 93 Np (237) | 94 Pu (244) | 95 Am (243) | 96 Cm (247) | 97 Bk (247) | 98 Cf (251) | 99 Es (252) | 100 Fm (257) | 101 Md (258) | 102 No (259) | 103 Lr (262) |