UNIVERSITY OF SIERRA LEONE

CHEM 123

FOURAH BAY COLLEGE

FIRST EXAMINATION FOR THE DEGREE OF B. Sc. HONOURS

LEVEL I

SECOND SEMESTER EXAMINATION

SATURDAY 8th SEPTEMBER 2018 09.30 – 12.45

CHEM 123 – REACTION MECHANISMS AND NATURALLY OCCURRING COMPOUNDS

TIME ALLOWED: 3 HOURS PLUS 15 MINUTES READING TIME

INSTRUCTIONS:

- THIS PAPER IS DIVIDED INTO THREE SECTIONS: A, B AND C; ANSWER ALL QUESTIONS IN SECTION A AND A TOTAL OF THREE QUESTIONS FROM SECTIONS B AND C, INCLLUDING AT LEAST ONE QUESTION FROM EACH SECTION

SECTION A (ANSWER ALL QUESTIONS)

SECTION B (ANSWER 1 OR 2 QUESTIONS)

SECTION C (ANSWER 1 OR 2 QUESTIONS)

The Periodic Table of the Elements

1	2											3	4	5	6	7	0
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	96.0 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La * lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac † actinium 89	[267] Rf rutherfordium 104	[268] Db dubnium 105	[271] Sg seaborgium 106	[272] Bh bohrium 107	[270] Hs hassium 108	[276] Mt meitnerium 109	[281] Ds damstadium 110	[280] Rg roentgenium 111	Elements with atomic numbers 112-116 have been reported but not fully authenticated						

140.1 Ce cerium 58	140.9 Pr praseodymium 59	144.2 Nd neodymium 60	[145] Pm promethium 61	150.4 Sm samarium 62	152.0 Eu europium 63	157.3 Gd gadolinium 64	158.9 Tb terbium 65	162.5 Dy dysprosium 66	164.9 Ho holmium 67	167.3 Er erbium 68	168.9 Tm thulium 69	173.1 Yb ytterbium 70	175.0 Lu lutetium 71
232.0 Th thorium 90	231.0 Pa protactinium 91	238.0 U uranium 92	[237] Np neptunium 93	[244] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[247] Bk berkelium 97	[251] Cf californium 98	[252] Es einsteinium 99	[257] Fm fermium 100	[258] Md mendelevium 101	[259] No nobelium 102	[262] Lr lawrencium 103

* **58 – 71** Lanthanides

† **90 – 103** Actinides

Section A

Answer all questions from this section.

A1. Propene reacts with hydrogen chloride to make two different organic products.

(a) Explain why two different organic products can be formed.

(b) Outline the mechanism for the formation of the major product.

(c) Draw the structure of the minor product.

[5]

A2. The reaction between 2-iodobutane and cyanide ions is known as an SN1 reaction.

(a) Outline the mechanism of this reaction.

(b) Use the mechanism of this reaction to explain the meaning of the term “SN1”.

[5]

A3. The acid-catalysed dehydration of butan-2-ol gives three different organic products.

(a) Outline the mechanism for the formation of one of these products.

(b) Draw the structures of the other two products.

[5]

A4. The reaction of ethane with bromine in the presence of UV light gives a variety of organic products, one of which is bromoethane.

(a) Outline the mechanism of the reaction between ethane and bromine to form bromoethane.

(b) Explain the role of the UV light in this reaction.

(c) Identify one other organic product that could be formed during this reaction.

[5]

A5. Methyl ethanoate is a common ester which can be prepared by reacting ethanoyl chloride with methanol.

(a) Outline the mechanism of this reaction.

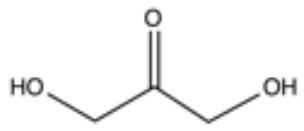
(b) Name the mechanism you have outlined.

(b) This method is not the standard industrial preparation for ethyl ethanoate. Suggest one reason for this.

[5]

A6. (a) Give the IUPAC names of the following organic compounds:

(i)



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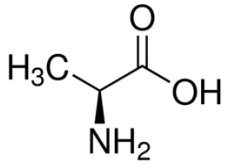

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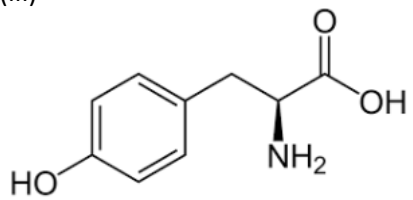

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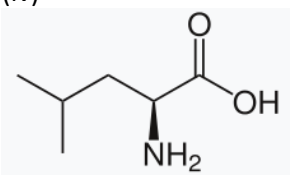


(b) Draw the structures of the following compounds:

(i) Glucose

(ii) Sucrose

(iii) Maltose

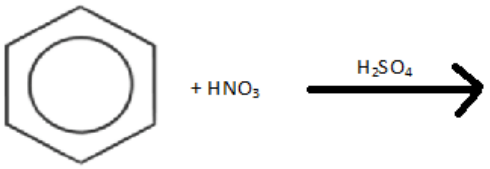
[5]

A7. (a) Sate and briefly explain any four factors that could affect the denaturation of a protein molecule.
(b) Explain the difference between glycosides and oligosaccharides.

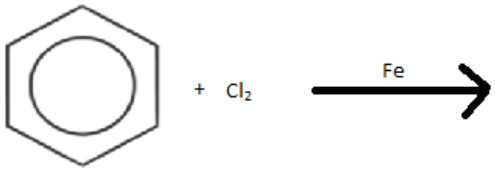
[5]

A8. Draw the main organic product of the following reactions:

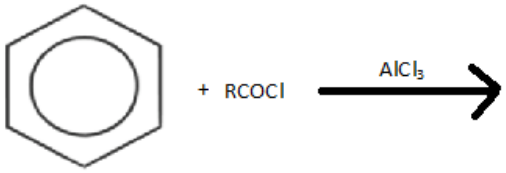
(a)



(b)



(c)



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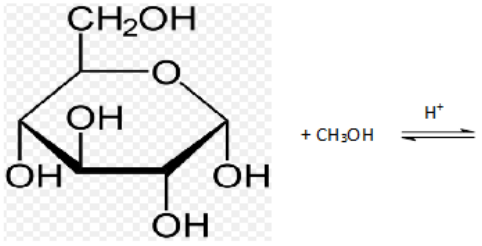

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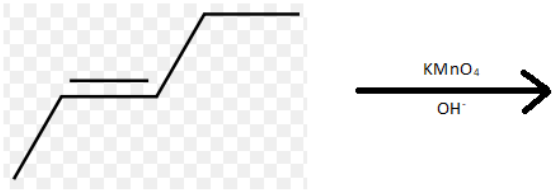


[5]

A9. (a) Briefly explain any three criteria that can be used to determine whether a compound is aromatic.
(b) Explain the difference between saturated and unsaturated fatty acids and give two examples of each.

[5]

A10. (a) Define the following terms:
(i) Saponification number
(ii) Iodine number
(iii) Transamination
(b) Give the structures of the following amino acids:
(i) Lysine
(ii) Isoleucine
(iii) Leucine

[5]

Section B

Answer one or two questions from this section.

B1. This question is about different mechanisms by which bromoalkanes can react and be formed.

(a) When 1-bromobutane reacts with hydroxide ions under certain conditions, the main product is butan-1-ol. Name and outline the mechanism for this reaction, write an equation for the reaction and state the role of the hydroxide ions in the reaction.

(6)

(b) When 2-bromomethylpropane reacts with hydroxide ions under the same conditions, the main product is methylpropan-2-ol. The mechanism for this reaction, however, is slightly different to the mechanism in (a).

(i) Explain **what** the difference is between the two mechanisms.

(ii) Explain **why** the two molecules react with hydroxide ions by different mechanisms.

(iii) Describe **how** you could determine experimentally which of the two mechanisms is taking place.

(6)

(c) When 1-bromobutane reacts with hydroxide ions under different conditions to those in (a), the main product is but-1-ene. Name and outline the mechanism for this reaction, write an equation for the reaction and state the role of the hydroxide ions in the reaction. Suggest the conditions which would favour the formation of but-1-ene rather than butan-1-ol.

(6)

(d) But-1-ene can be converted back to 1-bromobutane by reacting it with hydrogen bromide. However, 1-bromobutane is not the major product of this reaction.

(i) Draw the structure of the major product.

(ii) Name the mechanism by which this reaction takes place.

(iii) Explain why 1-bromobutane is not the major product.

(4)

(e) 1-bromobutane can also be prepared from butane. Write an equation for this reaction and explain why it is not a good way of making 1-bromobutane.

(3)

Total 25 marks

B2. This question is about the electrophilic substitution reactions of benzene.

(a) Explain the meaning of the terms “electrophile” and “substitution”. Explain why benzene reacts with electrophiles and tends to undergo substitution reactions.

(6)

(b) In one electrophilic substitution reaction known as alkylation, benzene can react with bromoethane in the presence of a catalyst (iron (III) bromide) at a temperature below 50 ^{o}C.

(i) Identify the electrophile in this reaction and write an equation to show its formation.

(ii) Outline the remainder of the mechanism of this reaction and name the main organic product.

(iii) Write an equation to show how the iron (III) bromide is regenerated.

(iv) Draw the structures of two alternative products that might be formed if the temperature of the reaction mixture was allowed to rise above 50 ^{o}C.

(10)

(c) The reaction in (b) is usually carried out by reacting benzene with ethene and hydrogen bromide, instead of reacting benzene directly with bromoethane. The same catalyst is used.

(i) Write an equation for the overall reaction taking place.

(ii) The electrophile in this reaction is the same as that in (b). Write an equation to show its formation from ethene and hydrogen bromide.

(iii) Explain why it is still important to add the iron (III) bromide.

(4)

(d) If benzene is mixed with propene in the presence of hydrogen bromide and iron (III) bromide at a temperature below 50 ^{o}C, two different products are formed.

(i) Draw the structures of the two products.

(ii) State and explain which of the two products is likely to be the major product.

(iii) If the minor product was the product you wanted, how could you make it more efficiently from benzene?

(6)

Max 25 marks

B3. This question is about the reactions of nucleophiles.

(a) Ammonia (NH_3) is a good nucleophile. It is able to react with chloroethane and it is also able to react with ethanoyl chloride.

(i) Explain why ammonia is a nucleophile and explain why chloroethane and ethanoyl chloride are both able to react with nucleophiles.

(ii) Write an equation for the reaction of ammonia with chloroethane and outline the mechanism for the reaction.

(iii) Write an equation for the reaction of ammonia with ethanoyl chloride and outline the mechanism for the reaction.)

(iv) Suggest why the reaction between ammonia and ethanoyl chloride is much faster than the reaction between ammonia and chloroethane

(12)

(b) Methylamine is also a good nucleophile and is able to react with both chloroethane and ethanoyl chloride by exactly the same mechanisms as ammonia.

(i) Write an equation for the reaction of methylamine with chloroethane, showing clearly the structure of the organic product.

(ii) Write an equation for the reaction of methylamine with ethanoyl chloride, showing clearly the structure of the organic product.

(4)

(c) Carbonyl compounds such as propanal can also react with nucleophiles.

(i) Outline the mechanism for the reaction of propanal with HCN and name the type of mechanism taking place. Write an equation for the overall reaction.

(ii) Explain why this reaction is fastest if the pH is between 3 and 5.

(iii) Suggest why it is not a good idea to carry out this reaction in the laboratory.

(iv) Identify another nucleophile which can react with propanal and write an equation for the reaction which would take place.

(9)

Total 25 marks

Section C

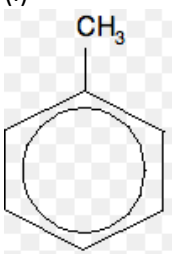
Answer one or two questions from this section.

C1. (a) (i) What are aromatic compounds? Give four examples of aromatic compounds.

(ii) State four characteristics of aromatic compounds.

(b) Give the IUPAC names of the following compounds:

(i)



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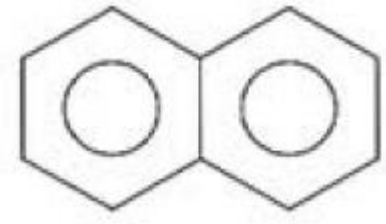
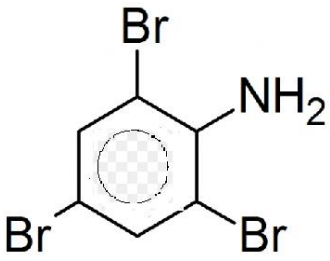
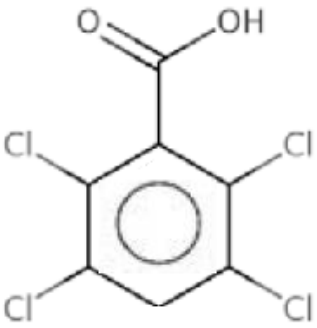


(iii)

(iv)



(v)



(c) Draw the structures of the following compounds:

(i) Amylopectin

(ii) Amylose

Total 25 marks

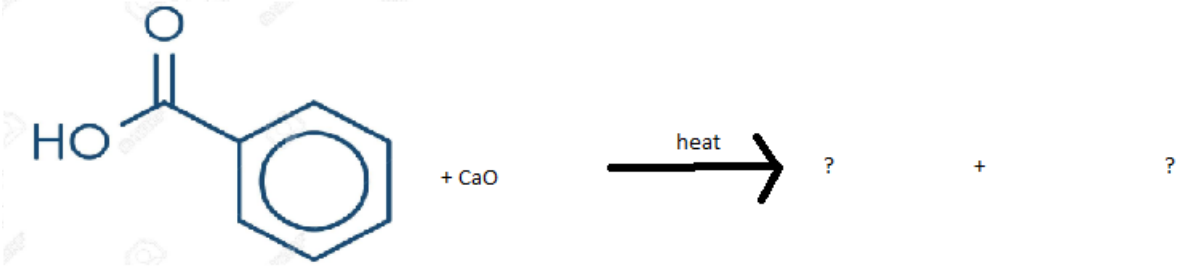
C2. (a) Using an appropriate chemical equation, comment on the following methods of reducing the carbon chain length in aldoses:

(i) Wohl's method

(ii) Rutt's method

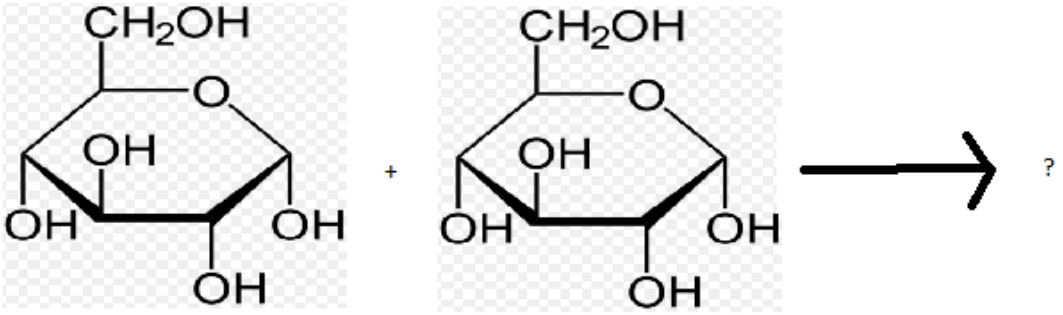
(b) Give the products of the following reactions:

(i)



(ii) $C_6H_6 + HNO_3 \rightarrow ? + ?$

(iii)



(c) Give the structures of any four heterocyclic compounds.

Total 25 marks

C3. (a) (i) What are essential amino acids?

(ii) Give the structures of the following acids: arginine, phenylalanine, valine, tyrosine, proline.

(b) (i) Give the molecular formulae of the following fatty acids: lauric acid, stearic acid, palmitic acid, oleic acid, linolenic acid, linoleic acid

(ii) What are osazones? Give the mechanism for the formation of an osazone.

(c) Define the following carbohydrates and give two examples of each:

(i) Glycosides

(ii) Polysaccharides

(iii) Disaccharides

(iv) Monosaccharides

(v) Oligosaccharides

Total 25 marks

END OF QUESTION PAPER