**IB Chemistry – HL**

**Topic 10 Questions**

**1.** Which statement about the reactions of halogenoalkanes with aqueous sodium hydroxide is correct?

A. Primary halogenoalkanes react mainly by an SN1 mechanism.

B. Chloroalkanes react faster than iodoalkanes.

C. Tertiary halogenoalkanes react faster than primary halogenoalkanes.

D. The rate of an SN1 reaction depends on the concentration of aqueous sodium hydroxide.

(Total 1 mark)

**2.** Which compound can exist as optical isomers?

A. H2NCH2COOH

B. CH2ClCH2Cl

C. CH3CHBrI

D. HCOOCH3

(Total 1 mark)

**3.** Which compound reacts most rapidly by a SN1 mechanism?

A. (CH3)3CCl

B. CH3CH2CH2CH2Br

C. (CH3)3CBr

D. CH3CH2CH2CH2Cl

(Total 1 mark)

**4.** Which compound can exist as optical isomers?

A. CH3CHBrCH3

B. CH2ClCH(OH)CH2Cl

C. CH3CHBrCOOH

D. CH3CCl2CH2OH

(Total 1 mark)

**5.** Which pair of compounds can be used to prepare CH3COOCH3?

A. Ethanol and methanoic acid

B. Methanol and ethanoic acid

C. Ethanol and ethanoic acid

D. Methanol and methanoic acid

(Total 1 mark)

**6.** Which pair of compounds can be used to prepare CH3CH2COOCH2CH3?

A. Ethanol and ethanoic acid

B. Ethanol and propanoic acid

C. Propanol and ethanoic acid

D. Propanol and propanoic acid

(Total 1 mark)

**7.** Nylon is a condensation polymer made up of hexanedioic acid and 1, 6 - diaminohexane.

Which type of linkage is present in nylon?

A. Amide

B. Ester

C. Amine

D. Carboxyl

(Total 1 mark)

**8.** How many chiral carbon atoms are present in a molecule of glucose?



A. 1 B. 2

C. 3 D. 4

(Total 1 mark)

**9.** Which amino acid can exist as optical isomers?



(Total 1 mark)

**10.** What is the product of the following reaction?

CH3CH2CH2CN + H2 

A. CH3CH2CH2NH2

B. CH3CH2CH2CH3

C. CH3CH2CH2CH2CH3

D. CH3CH2CH2CH2NH2

(Total 1 mark)

**11.** What is the correct IUPAC name for the following compound?



A. 4-methylbutanenitrile

B. 4-methylpentanenitrile

C. 2-methylbutanenitrile

D. 2-methylpentanenitrile

(Total 1 mark)

**12.** What is the organic product of the reaction between ethanol and ethanoic acid in the presence of sulfuric acid?

A. CH3CHO

B. CH3COOCH3

C. CH3CH2COOCH3

D. CH3COOCH2CH3

(Total 1 mark)

**13.** Which compound can exist as optical isomers?

A. (H2NCH2)2CHCOOH

B. H3CCH(CH3)CONH2

C. (H3C)3CCH(OH)CH3

D. CH3COOCH(CH3)2

(Total 1 mark)

**14.** One of the alcohols containing four carbon atoms exists as optical isomers.

Give the structural formula and name of this alcohol and explain why it exists as optical isomers. Outline how these two isomers could be distinguished.

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

..............................................................................................................................................

(Total 4 marks)

**15.** Many organic compounds can exist as isomers. Draw and name an isomer of ethanoic acid, CH3COOH.

(Total 2 marks)

**16.** Explain why butan-2-ol, CH3CH(OH)CH2CH3, exists as *enantiomers*, and describe how pure samples of the enantiomers can be distinguished experimentally.

(Total 3 marks)

**17.** Polyesters are formed in a condensation reaction. The structure of the repeat unit of a polyester is



(i) Draw the structures of the two monomers that react to form this polyester.

(2)

(ii) Identify the essential feature of the monomers in (i) that enable them to form a condensation polymer.

(1)

(Total 3 marks)

**19.** (i) State the meaning of the term *isomers*.

(1)

(ii) Draw the functional group isomers of C3H6O.

(2)

(iii) State the meaning of the term *optical isomers*. Draw the alcohol with the molecular formula C4H10O which exhibits optical isomerism and identify the chiral carbon atom.

(iv) Other than the optical isomers in (iii), draw the other **three** alcohol isomers of molecular formula C4H10O and identify the isomer that does not undergo oxidation.

(2)

(Total 8 marks)

**20.** (i) Draw the structural formula of the ester propyl ethanoate.

(1)

(ii) Deduce the name and draw the structural formula of the alcohol and carboxylic acid that react to form this ester.

Name of alcohol: .............................................................................................

Structural formula:

Name of carboxylic acid: .................................................................................

Structural formula:

(4)

(Total 5 marks)

**21.** The compound, 2-bromobutane, CH3CHBrCH2CH3, can react with sodium hydroxide to form compounds **F**, **G** and **H**.

Compound **F**, C4H10O, exists as a pair of optical isomers. Compounds **G** and **H**, C4H8, are structural isomers, and compound **H** exists as a pair of geometrical isomers.

(i) Draw the structures of the two optical isomers of **F**.

(2)

(ii) Outline the use of a polarimeter in distinguishing between the optical isomers.

(2)

(iii) Draw diagrams to show the shapes of the two geometrical isomers of **H**.

(2)

(iv) Draw the mechanism, using curly arrows to represent the movement of electron pairs, to show the formation of **G**.

(3)

(Total 9 marks)

**22.** A compound, **J**, has the molecular formula C2H4O2 and is obtained from a reaction between methanoic acid and methanol. Write an equation for this reaction and state the name of compound **J**.

(Total 3 marks)

**23.** (a) Compounds of formula C4H7Cl exhibits both geometrical and optical isomerism.

(i) Explain why C4H7Cl shows geometrical isomerism.

........................................................................................................................

........................................................................................................................

(1)

(ii) Draw the cis and trans isomers of C4H7Cl.

(2)

(iii) Draw the structural formula of C4H7Cl that shows only optical isomerism. Show the chiral carbon atom with “ \* ”.

(2)

(b) Explain why 1,2-dichlorocyclopropane has *cis* and *trans* isomers. Draw the structural formulas of the two isomers.

...................................................................................................................................

...................................................................................................................................

(3)

(Total 8 marks)

**24.** (a) There are **geometrical** isomers of the cyclic compound C4H6Cl2. Draw the structural formula of two isomers and explain why these two isomers exist.

cis-isomer trans-isomer

....................................................................................................................................

....................................................................................................................................

(3)

(b) (i) Draw the structural formulas of **two** isomers of but-2-ene-1,4-dioic acid.

(2)

(ii) State and explain which isomer will have a lower melting point.

.........................................................................................................................

.........................................................................................................................

.........................................................................................................................

(2)

(iii) Describe how the two isomers can be distinguished by a chemical test.

.........................................................................................................................

.........................................................................................................................

.........................................................................................................................

.........................................................................................................................

(2)

(c) Consider the following compounds:

1-chloropentane, 2-chloropentane, 3-chloropentane

(i) Identify the compound which exhibits optical isomerism and draw the structures of the **two** isomers.

.........................................................................................................................

(3)

(ii) Describe how these **two** isomers can be distinguished experimentally.

.........................................................................................................................

.........................................................................................................................

(1)

(Total 13 marks)

**25.** Compounds with the molecular formula C3H4Cl2 exist as several structural isomers, some of which are cyclic. Some of these structural isomers exist as geometric isomers.

(a) Explain why geometrical isomerism is possible in the non-cyclic isomers.

....................................................................................................................................

....................................................................................................................................

(1)

(b) Draw the structure of a non-cyclic structural isomer that does not exist as geometric isomers, and explain why geometrical isomerism is not possible in this compound.

....................................................................................................................................

....................................................................................................................................

(2)

(c) 1,3-Dichloropropene exists as geometric isomers. Draw and label the structures of its cis and trans isomers.

(2)

(d) Draw structures to show the two geometric isomers of 1,2-dichlorocyclopropane.

(2)

(Total 7 marks)

**26.** This question is about structural isomers and stereoisomers with the molecular formula C4H6Cl2.

(a) The compound 1,3-dichlorobut-1-ene can be used to illustrate two types of stereoisomerism. For each type of stereoisomerism, draw two structures to show the relationship between the two.

two geometrical isomers

two optical isomers

(4)

(b) Explain the term *racemic mixture*.

....................................................................................................................................

....................................................................................................................................

(1)

(c) Outline how the two optical isomers of 1,3-dichlorobut-1-ene can be distinguished from each other and from a racemic mixture.

....................................................................................................................................

....................................................................................................................................

....................................................................................................................................

....................................................................................................................................

(3)

(d) 1,3-dichlorocyclobutane exists as geometrical isomers. Draw the 3-dimensional structures of these isomers.

(2)

(Total 10 marks)

**27.** The molecular formula, C3H4Cl2 represents several isomeric compounds. Some isomers are cyclic and some are unsaturated.

(a) Draw the structures of two cyclic compounds that are structural isomers and state the names of both isomers.

(2)

(b) Two of the non-cyclic compounds have geometrical isomers. Draw the structures of these compounds and their geometrical isomers.

(2)

(Total 4 marks)

**IB Chemistry – HL**

**Topic 10 Answers**

**1.** C

**2.** C

**3.** C

**4.** C

**5.** B

**6.** B

**7.** A

**8.** D

**9.** B

**10.** D

**11.** B

**12.** D

**13.** C

**14.** CH3CH(OH)CH2CH3;

Accept more detailed formula.

butan-2-ol;

Accept 2-butanol.

ECF for correct name of another C4 alcohol.

contains a chiral/asymmetric carbon atom/four different groups around one  
carbon atom;

(plane of) plane-polarized light rotated in opposite directions; 4

[4]

**15.** methyl methanoate;

HCOOCH3;

Accept other correct alternative.

[2]

**16.** (the molecule contains a) chiral/asymmetric carbon atom/carbon atom with four  
different groups;

polarized light passed through;

(plane of polarization) rotated in opposite/different directions;

[3]

**17.** (i) HOCH2CH2OH;

HOOCC6H4COOH; 2

(ii) reactants have two functional groups/*OWTTE*; 1

[3]

**19.** (i) same molecular formula but different structural formulae/arrangement  
of atoms within a molecule/OWTTE; 1

(ii)



2

Accept unsaturated alcohol and cyclic alcohol as alternative answers.

If more than two correct isomers given  no penalty  but a third incorrect structure cancels a correct one. i.e. two correct, one incorrect equals **[1]**.

(iii) isomers that can rotate plane polarized light in opposite directions;

Accept two molecules/compounds, which are mirror images of each other.

Do not accept bend, reflect plane-polarized light.



correct identification of chiral carbon (\*); 3

(iv)



Award **[1]** mark for 3 structures



2

Penalize **[1]** mark for the omission of H in (i) to (iv).

[8]

**20.** (i)



1

(ii) propan-1-ol/1-propanol;  
CH3CH2CH2OH;

Accept full structural formula showing all bonds and atoms but no mark if H atoms missing

ethanoic acid/acetic acid;  
CH3COOH; 4

Accept full structural formula penalize missing Hs only once

ECF from incorrect ester in (i) above

[5]

**21.** (i)  
 2

Award **[2]** for both tetrahedral structures, or **[1]** if tetrahedral structure is not clear.

(ii) plane polarized light;  
rotation in opposite/different directions; 2

(iii)  
 2

(iv) curly arrow showing attack by –OH on end H;  
curly arrow showing C–Br bond fission;  
curly arrow showing formation of double bond;  
H2O and Br– shown as products; 3 max

Award **[1]** each for any three.  
If but-2-ene formed, award **[2 max]**.

[9]

**22.** CH3OH + HCOOH  HCOOCH3 + H2O

Award **[1]** for both reactants and **[1]** for both products (accept C2H4O2).

methyl methanoate; 3

[3]

**23.** (a) (i) no rotation possible due to double bond/ bond; 1

Accept restricted or hindered rotation.

(ii) 2



(iii)



2

Award **[1]** for the structure and **[1]** for showing \* on the correct carbon atom.

(b) restricted rotation because CC bond is now part of a cyclic system; 3



[8]

**24.** (a) restricted rotation because CC bond is now part of a cyclic system; 3



Award **[1]** for each correct 3D structure.

If correct structure, but not 3D, or wrongly labelled award **[1]** only.

Accept 1,3-disubstituted cyclo compound, or any other correct isomer.

(b) (i) 2



(ii) cis isomer (has lower melting point than the trans-isomer);

intramolecular hydrogen bonds/weaker intermolecular forces  
/less close packing; 2

(iii) (gentle) heating of a sample of each isomer;

cis isomer readily releases water vapour (forming a cyclic anhydride); 2

(c) (i) 2-chloropentane;



3

Award **[1]** for each correct 3D structure.

If correct structures, but not 3D, award **[1]** only.

(ii) rotation of the plane polarized light in opposite directions; 1

[13]

**25.** (a) restricted/no rotation around double bond/pi bond; 1

(b) Accept either of these structures



two identical atoms on one side of double bond/interchanging CH3  
and H/Cl and CH2Cl makes no difference; 2

(c)



Award **[0]** if structure of another isomer drawn.

Award **[1]** if both structures correct but unlabelled or wrongly labelled.

Award **[1]** for each correctly drawn and labelled structure. 2

(d)



2

Award **[0]** if structure of another isomer drawn.

[7]

**26.** (a)



one correct structural formula;

two distinct isomeric structures shown;



one correct structural formula shown as 3-D;

two distinct isomeric structures shown; 4

(b) it contains equal amounts/moles of the two optical isomers/enantiomers/  
d (dextro/dextrorotatory) and l(levo/levorotatory); 1

(c) polarimeter/plane-polarized light;

plane (of polarization) rotated in opposite directions;

no rotation for racemic mixture; 3

(d)



one correct structural formula;

two distinct isomeric structures shown; 2

[10]

**27.** (a)  
  
(*cis*- or *trans*-) 1,2 dichlorocyclopropane; 2

Award point for the correct name corresponding to the related isomer.  
Accept diagrams that do not display 3 dimensional structure.  
Award **[1 max]** for correct structures only, without the corresponding names.

(b)  
 2

[4]