Option G: Further organic chemistry (15/22 hours)

SL students study the core of these options and HL students study the whole option (the core and the extension material).

TOK: The relationship between a reaction mechanism and the experimental evidence to support it could be discussed. See 16.2.2.

Core material: G1–G8 are core material for SL and HL (15 hours).
Extension material: G9–G11 are extension material for HL only (7 hours).

G1 Electrophilic addition reactions

3 hours

	Assessment statement	Obj	Teacher's notes
G.1.1	Describe and explain the electrophilic addition mechanisms of the reactions of alkenes with halogens and hydrogen halides.	3	Include the application of Markovnikov's rule to predict the major product in the reactions of unsymmetrical alkenes with unsymmetrical reagents.
G.1.2	Predict and explain the formation of the major product in terms of the relative stabilities of carbocations.	3	

G2 Nucleophilic addition reactions

2 hours

	Assessment statement	Obj	Teacher's notes
G.2.1	Describe, using equations, the addition of hydrogen cyanide to aldehydes and ketones.	2	
G.2.2	Describe and explain the mechanism for the addition of hydrogen cyanide to aldehydes and ketones.	3	
G.2.3	Describe, using equations, the hydrolysis of cyanohydrins to form carboxylic acids.	2	

G3 Elimination reactions

1 hour

	Assessment statement	Obj	Teacher's notes
G.3.1	Describe, using equations, the	2	

	dehydration reactions of alcohols with phosphoric acid to form alkenes.		
G.3.2	Describe and explain the mechanism for the elimination of water from alcohols.	3	Use H^+ to represent the acid catalyst.

G4 Addition–elimination reactions

1 hour

	Assessment statement	Obj	Teacher’s notes
G.4.1	Describe, using equations, the reactions of 2,4-dinitrophenylhydrazine with aldehydes and ketones.	2	Mechanisms will not be assessed.

G5 Arenes

2.5 hours

	Assessment statement	Obj	Teacher’s notes
G.5.1	Describe and explain the structure of benzene using physical and chemical evidence.	3	**TOK:** See 14.3.1. For physical evidence, include a comparison of carbon–carbon bond lengths in alkanes, alkenes and benzene, and the number of structural isomers with the formula $C_6H_4X_2$. For chemical evidence, include a comparison of the enthalpies of hydrogenation of benzene, cyclohexene, 1,3-cyclohexadiene and 1,3,5-cyclohexatriene, and the tendency of benzene to undergo substitution rather than addition reactions.
G.5.2	Describe and explain the relative rates of hydrolysis of benzene compounds halogenated in the ring and in the side-chain.	3	Only the reactions with the OH^- ion will be assessed.

G6 Organometallic chemistry

2.5 hours

	Assessment statement	Obj	Teacher’s notes
G.6.1	Outline the formation of Grignard reagents.	2	Include the reaction of halogenoalkanes with magnesium metal.
G.6.2	Describe, using equations, the	2	Emphasize the formation of organic

	reactions of Grignard reagents with water, carbon dioxide, aldehydes and ketones.		molecules with an increased number of carbon atoms.

G7 Reaction pathways

1 hour

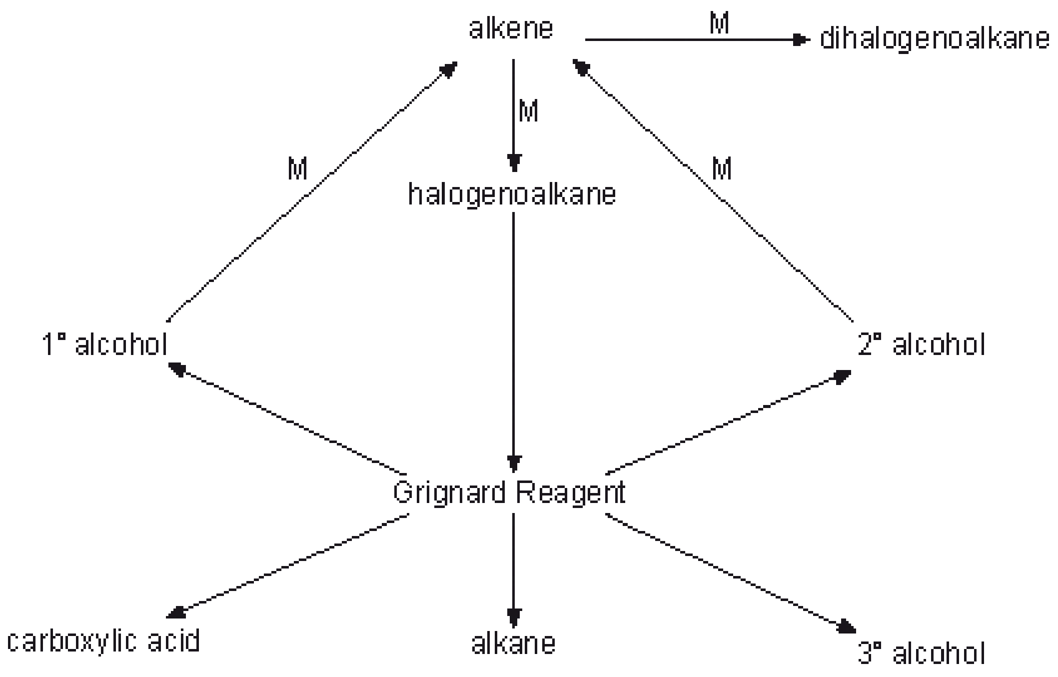
	Assessment statement	Obj	Teacher's notes
G.7.1	Deduce reaction pathways given the starting materials and the product.	3	Conversions with more than two stages will not be assessed. Reagents, conditions and equations should be included.

G8 Acid–base reactions

2 hours

	Assessment statement	Obj	Teacher's notes
G.8.1	Describe and explain the acidic properties of phenol and substituted phenols in terms of bonding.	3	Include a comparison of the acidities of alcohols, phenol and 2,4,6-trinitrophenol.
G.8.2	Describe and explain the acidic properties of substituted carboxylic acids in terms of bonding.	3	
G.8.3	Compare and explain the relative basicities of ammonia and amines.	3	Include primary, secondary and tertiary amines. Include the formation of salts from amines and the liberation of amines from salts using sodium hydroxide.

The compounds and reaction types in this option at SL are summarized in the following schemes:



HL G9 Addition–elimination reactions

2 hours

	Assessment statement	Obj	Teacher’s notes
G.9.1	Describe, using equations, the reactions of acid anhydrides with nucleophiles to form carboxylic acids, esters, amides and substituted amides.	2	Include the nucleophiles: water, alcohols, ammonia and amines. Aspirin and paracetamol can be made using reactions of this type.
G.9.2	Describe, using equations, the reactions of acyl chlorides with nucleophiles to form carboxylic acids, esters, amides and substituted amides.	2	Include the nucleophiles: water, alcohols, ammonia and amines.
G.9.3	Explain the reactions of acyl chlorides with nucleophiles in	3	

	terms of an addition–elimination mechanism.		

HL G10 Electrophilic substitution reactions

4 hours

	Assessment statement	Obj	Teacher's notes
G.10.1	Describe, using equations, the nitration, chlorination, alkylation and acylation of benzene.	2	Include the use of  for the benzene ring as well as formulas such as $C_6H_5NO_2$. The introduction of more than one group into the benzene ring will not be assessed here.
G.10.2	Describe and explain the mechanisms for the nitration, chlorination, alkylation and acylation of benzene.	3	Include the formation of NO_2^+ from the reaction between concentrated nitric and sulfuric acids, and the formation of Cl^+, R^+ and RCO^+ from reactions involving aluminium chloride as a halogen carrier catalyst.
G.10.3	Describe, using equations, the nitration, chlorination, alkylation and acylation of methylbenzene.	2	
G.10.4	Describe and explain the directing effects and relative rates of reaction of different substituents on a benzene ring.	3	Include the substituents $–CH_3$, –OH and $–NO_2$. Include the terms activating and deactivating. Only the introduction of one further group will be assessed, except for the formation of 2,4,6-trichlorophenol. The directing effects can be explained in terms of the charge distribution of the intermediates. The slightly increased reactivity due to the presence of $–CH_3$ can be explained in terms of its electron-releasing nature. The greatly increased reactivity due to the presence of –OH can be explained in terms of its partial donation of a non-bonded electron pair. The decreased reactivity due to the presence of $–NO_2$ can be explained in terms of its electron-withdrawing nature and lack of a non-bonded electron pair.

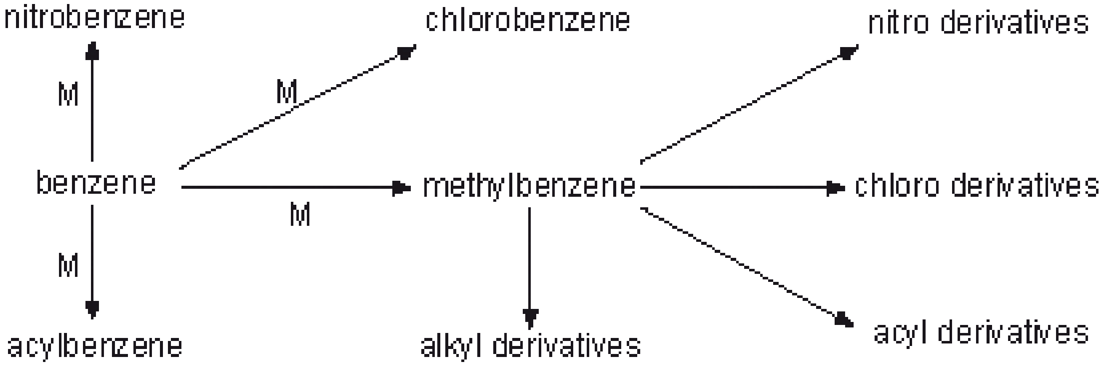
HL G11 Reaction pathways

1 hour

	Assessment statement	Obj	Teacher's notes

G.11.1	Deduce reaction pathways given the starting materials and the product.	3	Conversions with more than two stages will not be assessed. Reagents, conditions and equations should be included.

The compound and reaction types in this option at HL are summarized in the following scheme.



M = mechanism required