

## Topic 10: Organic Chemistry (HL)

### Markscheme Notes:

1. A markscheme often has more marking points than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.
2. Each marking point has a separate line and the end is signified by means of a semicolon (;).
3. An alternative answer or wording is indicated in the markscheme by a slash (/) – either wording can be accepted.
4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.
5. Words that are underlined are essential for the mark.
6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.
7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing **OWTTE** (or words to that effect).
8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. Indicate this with **ECF** (error carried forward).
10. Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **-1(U)** at the first point it occurs and **U** on the cover page.
11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

*e.g.* if the answer is 1.63:

2	<i>reject</i>
1.6	accept
1.63	accept
1.631	accept
1.6314	<i>reject</i>

Indicate the mark deduction by writing **-1(SD)** at the first point it occurs and **SD** on the cover sheet.

12. If a question specifically asks for the name of a substance, do not award a mark for a correct formula, similarly, if the formula is specifically asked for, do not award a mark for a correct name.
13. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.
14. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Answers:

1. D [1]

2. B [1]

3. A [1]

4. A [1]

5.  $\text{CH}_3\text{CH}_2\text{COOH} + \text{CH}_3\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{COOCH}_3 + \text{H}_2\text{O}$   
*[1] for reactants and [1] for products.*  
(concentrated) sulfuric acid/ $\text{H}_2\text{SO}_4$ ;  
*Do not accept just  $\text{H}^+$  or acid.*  
methyl propanoate; 4 [4]

6. (i)  
curly arrow going from lone pair/negative charge on O in  $\text{HO}^-$  to C;  
*Do not allow curly arrow originating on H in  $\text{HO}^-$ .*  
curly arrow showing Cl leaving;  
*Accept curly arrow either going from bond between C and Cl to Cl in 2-chloro-3-methylbutane or in the transition state.*  
representation of transition state showing negative charge, square brackets and partial bonds;  
*Do not penalize if HO and Cl are not at  $180^\circ$  to each other.*  
*Do not award M3 if OH ---- C bond is represented.*  
formation of organic product 3-methylbutan-2-ol **and**  $\text{Cl}^-$ ; 4

(ii)  $\text{OH}^-$  has a negative charge/higher electron density;  
greater attraction to the carbon atom (with the partial positive

charge) / OWTTE;  
Do not allow just greater attraction.

2

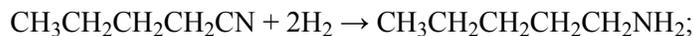
[6]



Accept  $\text{CN}^-$  for KCN and  $\text{Cl}^-$  for KCl.

pentanenitrile;

Allow 1-cyanobutane.



pentan-1-amine / 1-aminopentane / 1-pentylamine / 1-pentanamine;

Catalyst: nickel/Ni / palladium/Pd / platinum/Pt;

Penalize missing hydrogen once only.

5

[5]

8. C

[1]

9. A

[1]

10. B

[1]

11. (a)

correct isomer 3D structure;

correct name;

correct enantiomer 3D structure;

If compound incorrectly named award [2 max] for two correct 3D enantiomers, and [1 max] for a correct structure of an enantiomer not shown in 3D.

If non-optically active isomers given (e.g. 2-bromo-2-methyl-butane) award [1 max] if name and 3D structure are correct.

Accept condensed form for alkyl chain throughout.

3

(b) (i)

curly arrow going from lone pair/negative charge on O in  $\text{HO}^-$  to C bonded to Br;

*Do not allow curly arrow originating on H in HO<sup>-</sup> (e.g. originating on negative charge on H, i.e. lone pair/negative charge must be on O).*

curly arrow from C–Br bond to form Br<sup>-</sup> (this can also be shown in transition state);  
transition state showing overall negative charge; 3  
*Accept condensed formulas as long as curly arrows can still be shown, e.g.*

*If wrong formula used for halogenoalkane, e.g. 1-bromobutane award [2 max].*

(ii)

curly arrow from C–Br bond to form Br<sup>-</sup>;  
correct structure of tertiary carbocation;  
curly arrow going from lone pair/negative charge on O in HO<sup>-</sup> to C<sup>+</sup>; 3  
*If non-bonding pair not shown then arrow must originate from negative sign on O or the minus sign.  
Only penalize arrow from H once in (b).  
If wrong formula is used for 2-bromo-2-methylbutane award [2 max].*

(iii) the C bonded to the Br in 1-bromopentane is also bonded to two H atoms so can accommodate five groups around it in the transition state / *OWTTE*;  
the C bonded to the Br in 2-bromo-2-methylbutane has three other (bulky) groups bonded to it so cannot accommodate five groups around it in the transition state / *OWTTE*;  
2-bromo-2-methylbutane forms a tertiary carbocation which is stabilized by the positive inductive effect of the three alkyl groups / *OWTTE*;  
1-bromopentane would form a primary carbocation (if it went by S<sub>N</sub>2) which is much less stable as there is only one alkyl group exerting a positive inductive effect / *OWTTE*; 3 max

(iv) the boiling point of 1-bromopentane is higher than the boiling point of 2-bromo-2-methylbutane;  
2-bromo-2-methylbutane is more spherical in shape / less surface area in contact between molecules of 2-bromo-2-methylbutane than between molecules of 1-bromopentane / *OWTTE*;  
hence weaker intermolecular forces of attraction/van der Waals' forces of attraction between molecules of 2-bromo-2-methylbutane / *OWTTE*; 3

- (v) esterification / condensation;  
 $\text{CH}_3\text{-CO-O-(CH}_2\text{)}_4\text{CH}_3$  /  $\text{CH}_3\text{COO(CH}_2\text{)}_4\text{CH}_3$  /  
 $\text{CH}_3\text{COOCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$  /
- 2
- Accept CH<sub>3</sub>-CO-O-C<sub>5</sub>H<sub>11</sub>*
- (c) elimination;
- neither can exist as geometrical isomers as they contain the same two groups/atoms on one of the double bonded carbon atoms / *OWTTE*;
- 4
- [21]**
12. (i)  $n\text{HO-(CH}_2\text{)}_5\text{-OH} + n\text{HOOC-C}_6\text{H}_4\text{-COOH}$   
 $\rightarrow \text{H-[O-(CH}_2\text{)}_5\text{-O-CO-C}_6\text{H}_4\text{-CO-]}_n\text{-OH} + (2n - 1)\text{H}_2\text{O}$
- 3
- Award [1] for correct reactants, [1] for correct polyester and [1] for balanced water.*
- Award [3] if correct equation given for one molecule of diol reacting with one molecule of dicarboxylic acid.*
- i.e.*
- $\text{HO-(CH}_2\text{)}_5\text{-OH} + \text{HOOC-C}_6\text{H}_4\text{-COOH} \rightarrow \text{HO-(CH}_2\text{)}_5\text{-O-CO-C}_6\text{H}_4\text{-COOH} + \text{H}_2\text{O}$
- (ii) formation of polyesters/condensation polymers/synthetic fabrics;
- 1
- [4]**
13. D
- [1]**
14. A
- [1]**
15. D
- [1]**
16. C
- [1]**

17. (a) **A:** 1-bromobutane;  
**B:** 2-bromobutane;  
**C:** 2-bromo-2-methylpropane;  
**D:** 1-bromo-2-methylpropane;  
*Penalize incorrect punctuation, e.g. commas for hyphens, only once.*  
*Accept 2-bromomethylpropane and 1-bromomethylpropane for C and D respectively.* 4
- (b) (i) **C/2-bromo-2-methylpropane;**  
unimolecular nucleophilic substitution; 2
- (ii)  $\text{RBr} \rightarrow \text{R}^+ + \text{Br}^-$ ;  
*Allow use of 2-bromo-2-methylpropane instead of RBr.* 1
- (iii) **A/1-bromobutane/D/1-bromo-2-methylpropane;**  
  
curly arrow going from lone pair/negative charge on O in  $\text{OH}^-$  to C;  
*Do not allow curly arrow originating on H in  $\text{OH}^-$ .*  
curly arrow showing Br leaving;  
*Accept curly arrow either going from bond between C and Br to Br in 1-bromobutane or in the transition state.*  
representation of transition state showing negative charge, square brackets and partial bonds;  
*Do not penalize if HO and Br are not at  $180^\circ$  to each other.*  
*Do not award fourth mark if  $\text{OH} \cdots \text{C}$  bond is represented.* 4
- (c) (b)(i) no change as  $[\text{OH}^-]$  does not appear in rate equation/in the rate determining step;  
(b) (iii) rate doubles as the rate is proportional to  $[\text{OH}^-] / \text{OH}^-$  appears in the rate-determining/slow step / first order with respect to  $\text{OH}^-$ ;  
*Award [1] if correctly predicts no rate change for  $\text{S}_{\text{N}}1$  and doubling of rate for  $\text{S}_{\text{N}}2$  of without suitable explanation.* 2
- (d) rate of 1-bromobutane is faster;  
C–Br bond is weaker/breaks more easily than C–Cl bond; 2
- (e) 2-bromobutane/**B**;  
(plane-) polarized light shone through;  
enantiomers rotate plane of plane-polarized light to left or right/ opposite directions (by same amount);  
*Accept “turn” instead of “rotate” but not “bend/reflect”.*

physical properties identical (apart from effect on plane-polarized light);  
chemical properties are identical (except with other chiral compounds);  
*Do not accept "similar" in place of "identical".* 5

(f) (i) elimination; 1

(ii)

curly arrow going from lone pair/negative charge on O in  $\text{OH}^-$  to H on  $\beta\text{-C}$ ;  
*Do not allow curly arrow originating on H in  $\text{OH}^-$ .*

*Allow  $\text{C}_2\text{H}_5\text{O}^-$  instead of  $\text{OH}^-$ .*

curly arrow going from CH bond to form C=C bond;  
curly arrow showing Br leaving;

*Accept the following for first 3 marks.*

curly arrow showing Br leaving;  
representation of carbocation;

curly arrow going from lone pair/negative charge on O in  $\text{OH}^-$   
to H on C adjacent to  $\text{C}^+$  **and** curly arrow going from  
CH bond to form C=C bond;

two products formed: but-1-ene / but-2-ene/(cis) but-2-ene/  
(trans) but-2-ene;

*Award [1] for two correct answers.*

4 max

**[25]**

18. A

**[1]**

19. B

**[1]**

20. B

**[1]**

21. (a) compounds with same structural formula;  
*Do not allow "same molecular or chemical formula without the  
same structural formula".*

but different arrangement of atoms in space/spatial arrangement;

2

(b) (i)

Cis(-1,3-dichlorocyclobutane)

Trans(-1,3-dichlorocyclobutane)

*Need clear cis/trans structure and name for each mark.*

*Award [1] for 2 correct structures without names.*

2

- (ii) cis (higher boiling point);  
cis (more) polar / trans non-polar/less polar;  
cis experiences stronger (permanent) dipole-dipole interaction / trans  
experiences no/(much) less dipole-dipole interaction;  
*Do not accept just strong forces without reference to  
dipole-dipole interaction.*

3

[7]

22. (i)

*Accept CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>Br.*

*Accept CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>.*

*Penalize missing H atoms.*

1

- (ii) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>Br + KCN → CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CN + KBr;  
*Accept ionic equation.*

CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CN + 2H<sub>2</sub> → CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub>;

*Equation must be balanced for mark.*

*Accept LiAlH<sub>4</sub> in place of reaction with hydrogen.*

*For the second equation:*

Ni (as catalyst);

heat/150 °C;

4

[5]

23. (i) hot;

alcoholic OH<sup>-</sup> /NaOH/KOH;

C<sub>2</sub>H<sub>5</sub>Br + C<sub>2</sub>H<sub>5</sub>ONa → C<sub>2</sub>H<sub>4</sub> + NaBr + C<sub>2</sub>H<sub>5</sub>OH /

C<sub>2</sub>H<sub>5</sub>Br + NaOH → C<sub>2</sub>H<sub>4</sub> + NaBr + H<sub>2</sub>O;

*Accept ionic equation with C<sub>2</sub>H<sub>5</sub>O<sup>-</sup> or OH<sup>-</sup>.*

3

- (ii) OH<sup>-</sup> reacts with ethanol to form ethoxide ion/C<sub>2</sub>H<sub>5</sub>OH + OH<sup>-</sup> → C<sub>2</sub>H<sub>5</sub>O<sup>-</sup> + H<sub>2</sub>O;

curly arrow going from lone pair/negative charge on O in C<sub>2</sub>H<sub>5</sub>O<sup>-</sup> /CH<sub>3</sub>CH<sub>2</sub>O<sup>-</sup> to  
H on β-C;

Accept arrow origin from  $\text{OH}^-$  but do not allow curly arrow originating on H in  $\text{OH}^-$ .

Accept  $\text{OH}^-$  in place of  $\text{C}_2\text{H}_5\text{O}^-$  (to form  $\text{H}_2\text{O}$ ).

curly arrow going from CH bond to form C=C bond;  
curly arrow showing Br leaving;  
structural formula of organic product  $\text{CH}_2=\text{CH}_2$ ;

Award **[4 max]** for E1 mechanism (unstable primary carbocation)

curly arrow showing Br leaving;  
representation of primary carbocation;  
curly arrow going from lone pair on O in  $\text{H}_2\text{O}$  to H on C adjacent to  $\text{C}^+$  **and** curly arrow going from CH bond to form C=C bond;  
structural formula of organic product  $\text{CH}_2=\text{CH}_2$ ;

5

**[8]**

24. D

**[1]**

25. B

**[1]**

26. B

**[1]**

27. C

**[1]**

28. (a)

First and second structures should be mirror images.  
Tetrahedral arrangement around carbon must be shown.

2

- (b) (i) order with respect to  $\text{OH}^- = 0$ ;  
order with respect to X = 1;  
rate =  $k[\text{X}]$ ;  
Award **[3]** for final correct answer.

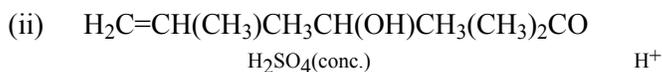
3

- (ii)  $0.2(0);$   
 $\text{min}^{-1};$  2
- (iii) 2-bromo-2-methyl-propane;  
*Do not penalize missing hyphens or added spaces.*  
*Accept 2-bromomethylpropane.*  
tertiary (structure); 2
- (iv)  $\text{C}_4\text{H}_9\text{Br} \rightarrow \text{C}_4\text{H}_9^+ + \text{Br}^-$  / in equation with curly arrows **and** slow;  
 $\text{C}_4\text{H}_9^+ + \text{OH}^- \rightarrow \text{C}_4\text{H}_9\text{OH}$  / in equation with curly arrows **and** fast;  
*No penalty if primary structure is shown.*  
*No credit for  $\text{S}_{\text{N}}2$  mechanism, except by ECF.* 2
- [11]**
29. C [1]
30. D [1]
31. B [1]
32. B [1]
33. D [1]
34. (a) (i)  $\text{CH}_3\text{CH}_2\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 + \text{HBr}$  /  
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 + \text{H}_2\text{O} + \text{Br}^-$ ;  
alcoholic NaOH/OH<sup>-</sup>;

- reflux / heat;  
*Penalize missing Hs once only throughout the question* 3
- (ii) elimination reaction;  
*Then accept either E1 or E2 mechanism.*  
*E1*  
 curly arrow showing bromine leaving the halogenoalkane;  
 OH<sup>-</sup> acting as base on the intermediate carbocation;  
*E2*  
 curly arrow showing OH<sup>-</sup> acting as base on H bonded to C;  
 concerted curly arrows showing Br leaving C-Br; 3
- (iii) CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>Br + NH<sub>3</sub> → CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>NH<sub>2</sub> + HBr;  
 ammonia/NH<sub>3</sub>;  
 warm / excess ammonia (to prevent secondary amines etc.); 3
- (iv)  
 curly arrow from ammonia (to form transition state);  
 correct transition state;  
 curly arrow from bond to Br atom in either the first or second step;  
 formation of HBr and organic product;  
*Accept a second molecule of NH<sub>3</sub> removing H<sup>+</sup> from the transition state  
 to give NH<sub>4</sub><sup>+</sup> and Br<sup>-</sup> as products.* 4
- (b) (i)  
*Award [1] for correct structure and [1] for correct 3-D  
 representation of both enantiomers.* 2
- (ii) polarimeter (to measure angle of rotation);  
 the plane of plane-polarized light rotates in opposite directions  
 (by the different enantiomers); 2
- (iii) 2-bromo-2-methylpropane is tertiary / 1-bromobutane is primary;  
 2-bromo-2-methylpropane goes by S<sub>N</sub>1 / 1-bromobutane by S<sub>N</sub>2;  
 intermediate carbocation more stable for tertiary;  
 no space around tertiary carbon for five groups (in S<sub>N</sub>2  
 transition state); 3 max

[20]

35. (i) amide / peptide; 1
- (ii)  $\text{H}_2\text{N}(\text{CH}_2)_6\text{NH}_2$ ;  
 $\text{HOOC}(\text{CH}_2)_8\text{COOH}$  /  $\text{ClOC}(\text{CH}_2)_8\text{COCl}$ ; 2
- (iii)  $n\text{HOOC}(\text{C}_6\text{H}_4)\text{COOH} + n\text{HOCH}_2\text{CH}_2\text{OH}$   
 $\rightarrow \text{HO}-(\text{---OCC}_6\text{H}_4\text{COOCH}_2\text{CH}_2\text{O---})_n\text{---H} + (2n - 1)\text{H}_2\text{O}$ ;  
*Award [1] for correct organic product and [1] for  $(2n - 1)\text{H}_2\text{O}$ .*  
*Accept  $\text{---}(\text{---OCC}_6\text{H}_4\text{COOCH}_2\text{CH}_2\text{O---})_n\text{---}$  for the organic product.* 2 **[5]**
36. A **[1]**
37. C **[1]**
38. D **[1]**
39. (i)  $\text{CH}_3\text{CH}_2\text{OH} \xrightarrow{\text{H}^+} \text{CH}_3\text{COOH} \xrightarrow{\text{H}_2\text{SO}_4} \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}$   
*Structural formulas of reactants and products*  
 $\text{CH}_3\text{CH}_2\text{OH}$  **and**  $\text{CH}_3\text{COOH}$ / $\text{CH}_3\text{CO}_2\text{H}$  **and**  $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$  (+  $\text{H}_2\text{O}$ );  
*Conditions/reagents used*  
 reflux with named suitable acidified oxidizing agent **and** then heat with alcohol and sulfuric acid;  
*Suitable oxidizing agents are potassium dichromate/ $\text{K}_2\text{Cr}_2\text{O}_7$  / sodium dichromate/ $\text{Na}_2\text{Cr}_2\text{O}_7$  / dichromate/ $\text{Cr}_2\text{O}_7^{2-}$  / potassium manganate(VII)/potassium permanganate/ $\text{KMnO}_4$  / permanganate/manganate (VII)/ $\text{MnO}_4^-$ .*  
*Accept  $\text{H}^+/\text{H}_2\text{SO}_4$  instead of sulfuric acid and acidified.*  
*Award [1] for structural formulas of reactants and products and [1] for the correct conditions/reagents used.* 2



Structural formulas of reactants and products  
 $\text{H}_2\text{C}=\text{CH}(\text{CH}_3)$  **and**  $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$  **and**  $(\text{CH}_3)_2\text{CO}$ ;

*Conditions/reagents used*

water/ $\text{H}_2\text{O}$  and sulfuric acid/ $\text{H}_2\text{SO}_4$  / dilute acid medium and heat/reflux  
 with suitable acidified oxidizing agent;

*Suitable oxidising agents are potassium dichromate/ $\text{K}_2\text{Cr}_2\text{O}_7$  / sodium  
 dichromate/ $\text{Na}_2\text{Cr}_2\text{O}_7$  / dichromate/ $\text{Cr}_2\text{O}_7^{2-}$  / potassium manganate(VII)/  
 potassium permanganate/ $\text{KMnO}_4$  / permanganate/manganate (VII)/ $\text{MnO}_4^-$ .*

*Accept  $\text{H}^+/\text{H}_2\text{SO}_4$  instead of acidified.*

*Note: If primary alcohol is given as product of first step, and everything  
 else correct, award [1 max].*

*Accept either full or condensed structural formulas throughout the question.*

2

[4]

40.

curly arrow going from O of  $^-\text{OCH}_2\text{CH}_3$  attacking hydrogen;

*Allow the curly arrow to originate from either the lone pair or O of  $^-\text{OCH}_2\text{CH}_3$  but  
 not from H of  $^-\text{OCH}_2\text{CH}_3$ .*

*Do not award first mark if curly arrow originates from O of  $\text{NaOCH}_2\text{CH}_3$ .*

curly arrow going from the C–H bond on the  $\beta$  carbon to the bond joining the  
 $\alpha$  carbon to the  $\beta$  carbon **and** curly arrow showing Br acting as leaving group;  
 formation of  $(\text{CH}_3)_2\text{C}=\text{CH}_2$  **and**  $\text{Br}^-$ ;

*Allow formation of  $\text{NaBr}$  for third marking point, if was used (incorrectly)  
 in the mechanism. Use of  $\text{NaOCH}_2\text{CH}_3$  with curly arrow originating on  
 O of  $\text{NaOCH}_2\text{CH}_3$  is penalized already in the first marking point.*

*Accept alternative E1 type mechanism*

curly arrow showing Br acting as leaving group to form carbocation;

curly arrow going from O of  $^-\text{OCH}_2\text{CH}_3$  attacking hydrogen;

formation of  $(\text{CH}_3)_2\text{C}=\text{CH}_2$  **and**  $\text{Br}^-$ ;

*No marks awarded if a substitution mechanism is given.*

3

[3]

41. (i) compounds with the same (molecular formula and) structural formula but  
 different arrangements of atoms in space / *OWTTE*;

1

(ii)

*Allow [1 max] if structures are correct but arrangement of groups in space  
 does not clearly show the cis/ trans isomerism.*

(iii)

*Allow [1 max] if the structures are correct but it is not clear that they are mirror images.*

2

**[3]**

42. A

**[1]**

43. C

**[1]**

44. D

**[1]**

45. B

**[1]**

46. (i)

2

(ii) no rotation possible due to double bond/pi bond;  
*Accept hindered or restricted rotation.*

1

(iii)

correct structural formula;  
chiral carbon atom identified;

2

**[5]**

47. (i) trans has the higher melting point;  
trans isomer has (predominantly) intermolecular hydrogen bonding;  
cis isomer has (predominantly) intramolecular hydrogen bonding;

3

	(ii)	cis isomer readily releases water (vapour forming a cyclic anhydride); <i>Accept opposite arguments for trans isomer.</i>	1	<b>[4]</b>
48.	(i)	S <sub>N</sub> 2;	1	
	(ii)	curly arrow going from CN <sup>-</sup> to C; curly arrow showing Br leaving; <i>Curly arrow may be represented on transition state.</i> representation of transition state, showing negative charge and dotted lines; products;	4	
	(iii)	CH <sub>3</sub> CH <sub>2</sub> CN + 2H <sub>2</sub> → CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub> ; Ni / Pt / Pd;	2	<b>[6]</b>
49.	(i)	CH <sub>3</sub> CH <sub>2</sub> Br + OH <sup>-</sup> → CH <sub>3</sub> CH <sub>2</sub> OH + Br <sup>-</sup> ; CH <sub>3</sub> CH <sub>2</sub> Br + OH <sup>-</sup> → CH <sub>2</sub> =CH <sub>2</sub> + H <sub>2</sub> O + Br <sup>-</sup> ; <i>Accept KOH and KBr in the balanced equations</i> dilute KOH compared to concentrated KOH; aqueous KOH compared to ethanolic KOH; warm/40–50 °C compared to hot/80-100 °C; Accept any two reaction conditions.	4 max	
	(ii)	curly arrow from O to H; curly arrow from C–H to C–C; curly arrow showing Br leaving; products CH <sub>2</sub> =CH <sub>2</sub> + Br <sup>-</sup> + C <sub>2</sub> H <sub>5</sub> OH/H <sub>2</sub> O;	4	
	(iii)	addition;	1	<b>[9]</b>
50.	D			<b>[1]</b>

51.	B		[1]
52.	D		[1]
53.	C		[1]
54.	(a)	( <i>cis-</i> or <i>trans-</i> ) 1,2 dichlorocyclopropane;	2
		<i>Award point for the correct name corresponding to the related isomer.</i>	
		<i>Accept diagrams that do not display 3 dimensional structure.</i>	
		<i>Award [1 max] for correct structures only, without the corresponding names.</i>	
	(b)		2
			[4]
55.	(i)		2
		<i>Award [2] for both tetrahedral structures, or [1] if tetrahedral structure is not clear.</i>	
	(ii)	plane polarized light; rotation in opposite/different directions;	2
	(iii)		2
	(iv)	curly arrow showing attack by $\text{OH}^-$ on end H; curly arrow showing C–Br bond fission; curly arrow showing formation of double bond; $\text{H}_2\text{O}$ and $\text{Br}^-$ shown as products;	3 max

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

**[9]**



*Award [1] for both reactants and [1] for both products (accept  $\text{C}_2\text{H}_4\text{O}_2$ ).*

methyl methanoate;

3

**[3]**