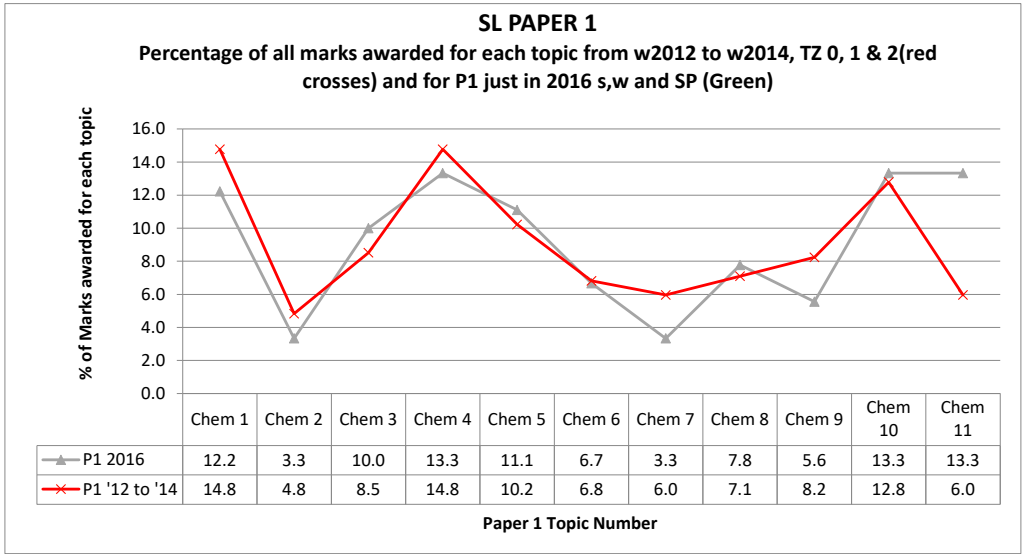
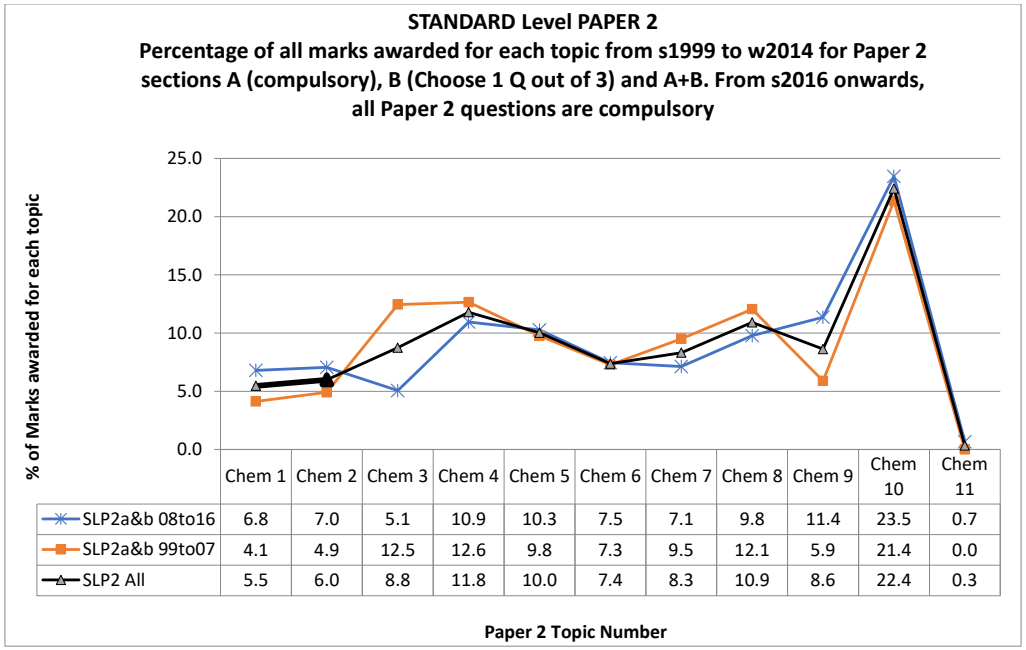
Name

IB SL 10 EQ 16w to 99s P2 Section A & B 433marks

Before 2016 paper 2 was included 4 section B questions, of which you had to chose 2. After 2016 all questions became compulsory on Paper 2



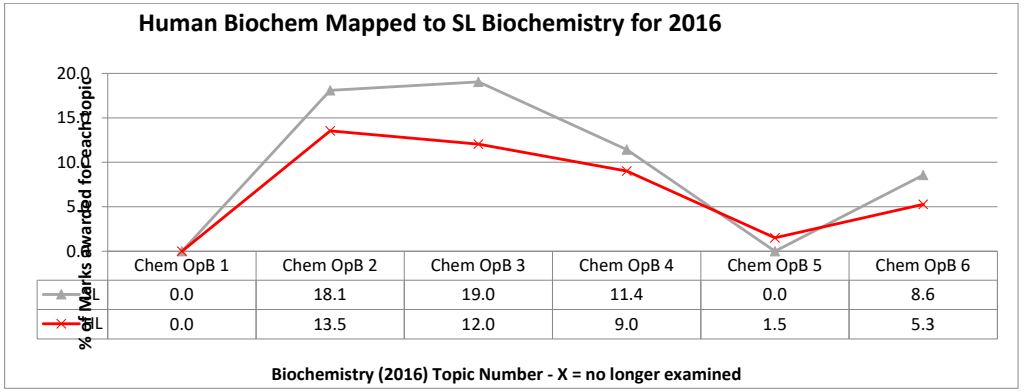
	Chem 1	Chem 2	Chem 3	Chem 4	Chem 5	Chem 6	Chem 7	Chem 8	Chem 9	Chem 10	Chem 11
P1 2016	12.2	3.3	10.0	13.3	11.1	6.7	3.3	7.8	5.6	13.3	13.3
P1 '12 to '14	14.8	4.8	8.5	14.8	10.2	6.8	6.0	7.1	8.2	12.8	6.0



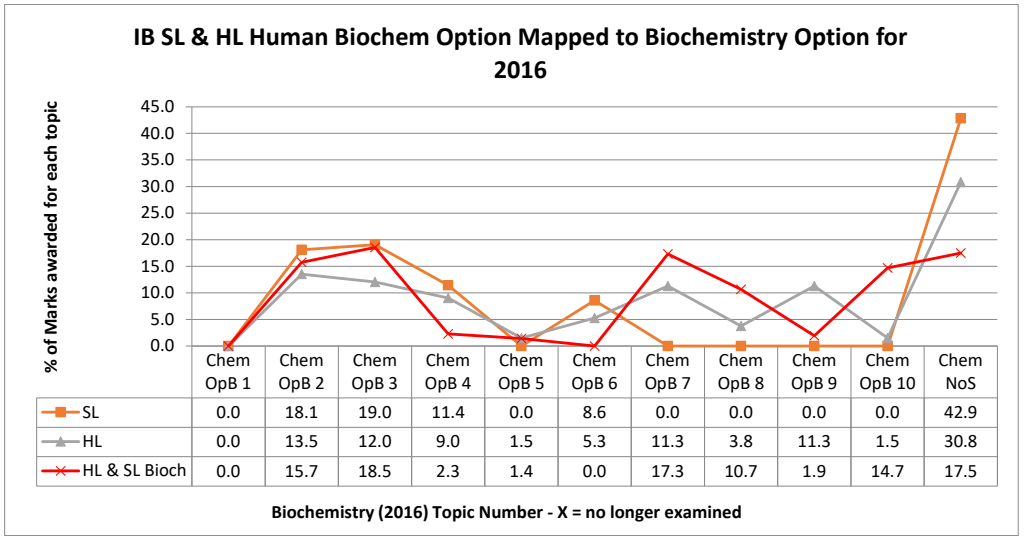
	Chem 1	Chem 2	Chem 3	Chem 4	Chem 5	Chem 6	Chem 7	Chem 8	Chem 9	Chem 10	Chem 11
SLP2a&b 08to16	6.8	7.0	5.1	10.9	10.3	7.5	7.1	9.8	11.4	23.5	0.7
SLP2a&b 99to07	4.1	4.9	12.5	12.6	9.8	7.3	9.5	12.1	5.9	21.4	0.0
SLP2 All	5.5	6.0	8.8	11.8	10.0	7.4	8.3	10.9	8.6	22.4	0.3

All topics ranked according to their impact on your final grade using exam papers from 1999 to 2016

	TOPICS and IA													
	IA	10	Option	N.ofSci	4	5	8	3	1	9	7	6	2	11
Paper 1		12.8			14.8	10.2	7.1	8.5	14.8	8.2	6.0	6.8	4.8	6.0
Paper 2 16 to 08		23.5			10.9	10.3	9.8	5.1	6.8	11.4	7.1	7.5	7.0	0.7
Paper 2 07 to 99		21.4			12.6	9.8	12.1	12.5	4.1	5.9	9.5	7.3	4.9	0.0
Paper 2 ALL		22.4			11.8	10.0	10.9	8.8	5.5	8.6	8.3	7.4	6.0	0.3
Paper 3		0.0	57.1	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total % All Marks, Weighted	20	11.5	11.4	8.6	7.7	6.1	5.8	5.2	5.1	5.1	4.5	4.3	3.4	1.3
Rank Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14



	Chem OpB 1	Chem OpB 2	Chem OpB 3	Chem OpB 4	Chem OpB 5	Chem OpB 6
HL	0.0	18.1	19.0	11.4	0.0	8.6
SL	0.0	13.5	12.0	9.0	1.5	5.3

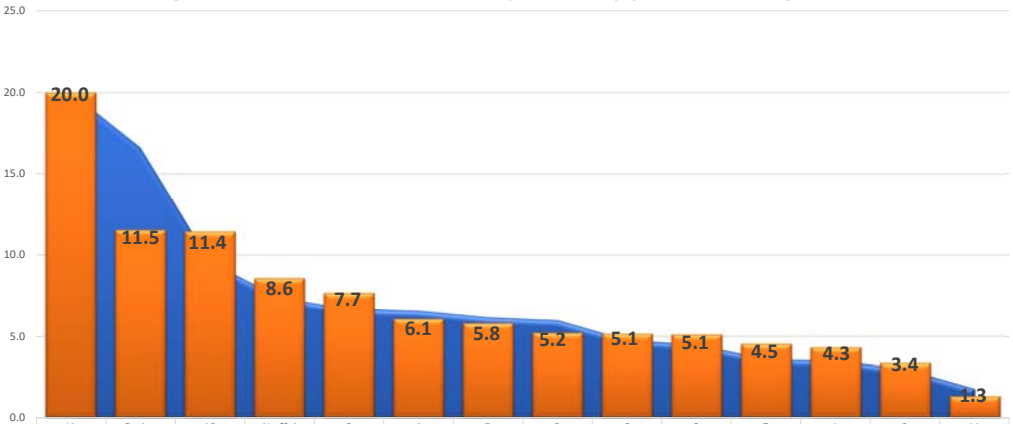


	Chem OpB 1	Chem OpB 2	Chem OpB 3	Chem OpB 4	Chem OpB 5	Chem OpB 6	Chem OpB 7	Chem OpB 8	Chem OpB 9	Chem OpB 10	Chem NoS
SL	0.0	18.1	19.0	11.4	0.0	8.6	0.0	0.0	0.0	0.0	42.9
HL	0.0	13.5	12.0	9.0	1.5	5.3	11.3	3.8	11.3	1.5	30.8
HL & SL Bioch	0.0	15.7	18.5	2.3	1.4	0.0	17.3	10.7	1.9	14.7	17.5

Essentially, Nature of Science (NoS) is almost half of the paper, sections after 6, so 7, 8 9 & 10 are only found in HL. This is older data and will be updated in late 2019 (I stopped teaching IB in 2016, teaching A levels instead and started again in the second half of 2019).

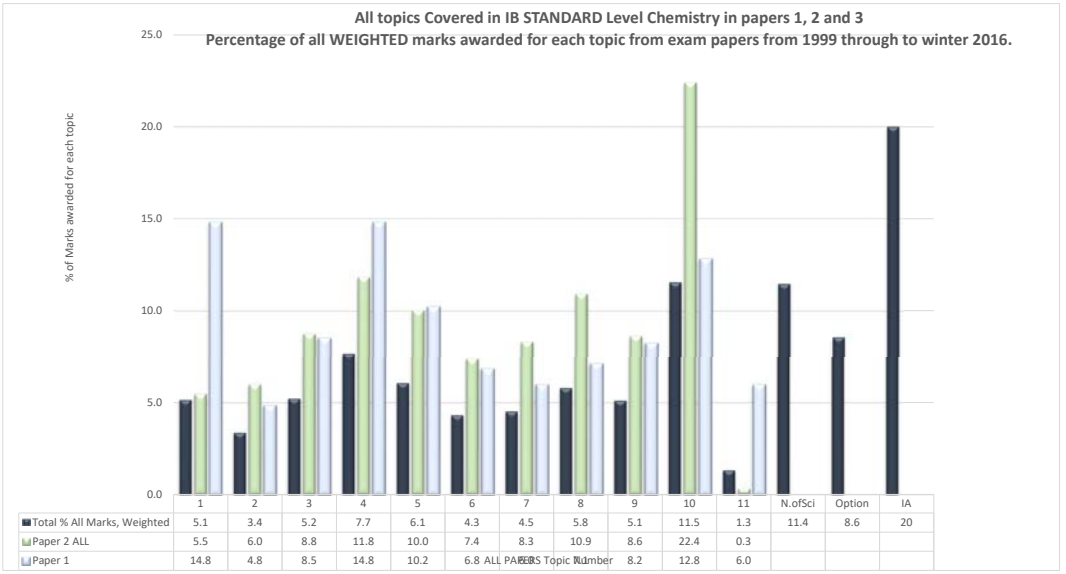
Name

Standard and Higher Level components compared



	IA	Option	10	N.ofSci	8	4	5	9	6	3	7	1	2	11
HL	20.0	16.6	9.6	7.4	6.7	6.6	6.2	6.0	4.7	4.5	3.6	3.5	3.0	1.8
SL	20.0	11.5	11.4	8.6	7.7	6.1	5.8	5.2	5.1	5.1	4.5	4.3	3.4	1.3

Essentially, IA has the exact same weight, the Option in HL is almost 50% more important than in SL but Topic 10 is more important in SL than HL. All other topics contribute almost equally to a SL and HL grade.



	1	2	3	4	5	6	7	8	9	10	11	N.ofSci	Option	IA
Total % All Marks, Weighted	5.1	3.4	5.2	7.7	6.1	4.3	4.5	5.8	5.1	11.5	1.3	11.4	8.6	20
Paper 2 ALL	5.5	6.0	8.8	11.8	10.0	7.4	8.3	10.9	8.6	22.4	0.3			
Paper 1	14.8	4.8	8.5	14.8	10.2	6.8	8.3	11.1	8.2	12.8	6.0			

ALL PAPERS Topic Number

The dark blue bars are where your final IB grade will be from:

1. Your IA is the single most important part of your IB SL, more important than even the Option. Imagine how much time in class, at home and in revision you have or will give to topics 9, 10 and 11. **Your IA, on average, will be worth more to your final grade than all those combined.**
2. The Option is the most important topic for your IB grade compared to the everything else

Topic 10, Organic Chemistry, is by far the most important topic for papers 1 and 2.

Q# 1/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q5

5. Propane and propene are members of different homologous series.

(a) Draw the full structural formulas of propane and propene. [1]

Propane:

Propene:

(b) Both propane and propene react with bromine.

(i) State an equation and the condition required for the reaction of 1 mol of propane with 1 mol of bromine. [2]

(ii) State an equation for the reaction of 1 mol of propene with 1 mol of bromine. [1]

(iii) State the type of each reaction with bromine. [1]

Propane:

Propene:

Q# 2/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q1

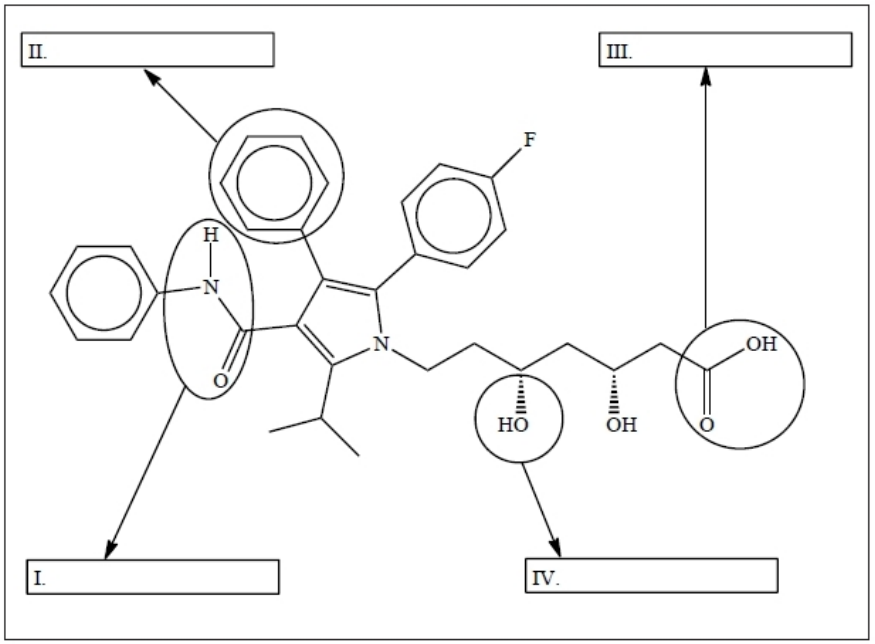
(d) Ethane-1,2-diol can be oxidized first to ethanedioic acid, $(COOH)_2$, and then to carbon dioxide and water. Suggest the reagents to oxidize ethane-1,2-diol. [1]

Q# 3/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q4 NOT with (b)(i & ii)

4. The biopharmaceutical industry is now a global contributor to the world economy.

(a) Atorvastatin, a drug used to lower cholesterol, recently gained attention from the global media.

Atorvastatin has the structure shown below.



Identify the **four** functional groups, I, II, III and IV. *[2]*

(b) Bute, a painkiller used on horses, has caused widespread concern recently because analytical tests showed that it entered the food chain through horse meat labelled as beef. The drug is suspected of causing cancer.

Bute has molecular formula of

$C_{19}H_{20}N_2O_2$

(iii) Deduce the degree of unsaturation (index of hydrogen deficiency – IHD) of bute. *[1]*

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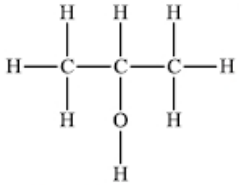
. . . . . .
. . . . . .

X is this molecule:



(iii) **Y** is an isomer of **X** containing a different functional group. State the condensed structural formula of **Y**. *[1]*

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

(v) Both **X** and **Y** are soluble in water. Deduce whether or not both **X** and **Y** show hydrogen bonding with water molecules, representing any hydrogen bonding present by means of a diagram. *[2]*

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

(vi) **X** reacts with acidified potassium dichromate(VI) solution to form **Q** and with ethanoic acid to form **W**. Deduce the condensed structural formula of **Q** and **W**. *[2]*

Q:

. . . . . .

W:

. . . . . .

(vii) Apply IUPAC rules to state the name of compound **Q**. *[1]*

. . . . . .

Q# 4/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q2

2. One of the main constituents of acid deposition is sulfuric acid, H_2SO_4. This acid is formed from the sulfur dioxide pollutant, SO_2.

A mechanism proposed for its formation is:

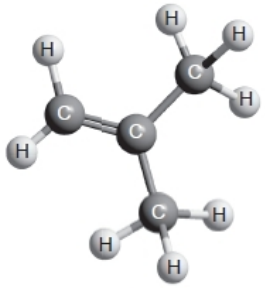
$$HO\bullet(g) + SO_2(g) \rightarrow HOSO_2(g)$$
$$HOSO_2(g) + O_2(g) \rightarrow HOO\bullet(g) + SO_3(g)$$
$$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$$

(a) (i) State what the symbol (•) represents in the species shown in this mechanism. *[1]*

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

Q# 5/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q4

4. Alkenes are widely used in the production of polymers. The compound **A**, shown below, is used in the manufacture of synthetic rubber.



A

(a) (i) State the name, applying IUPAC rules, of compound **A**. [1]

. . . . . .

(ii) Draw a section, showing three repeating units, of the polymer that can be formed from compound **A**. [1]

(iii) Compound **A** is flammable. Formulate the equation for its complete combustion. [1]

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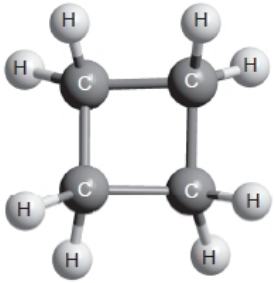
(b) Compound **B** is related to compound **A**.



B

(i) State the term that is used to describe molecules that are related to each other in the same way as compound **A** and compound **B**. [1]

. . . . . .

(ii) Suggest a chemical test to distinguish between compound **A** and compound **B**, giving the observation you would expect for each. [2]

Test:

. . . . . .

. . . . . .

Observation with **A**:

. . . . . .

Observation with **B**:

. . . . . .

Q# 6/ IB Chem/2013/s/tz1/Paper 2 Section B/Standard Level/

8. Ethene belongs to the homologous series of the alkenes.

(a) (i) Outline **three** features of a homologous series. *[3]*

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(ii) Describe a test to distinguish ethene from ethane, including what is observed in **each** case. *[2]*

(iii) Bromoethane can be produced either from ethene or from ethane. State an equation for **each** reaction. *[2]*

(b) A bromoalkane, C_4H_9Br, reacts with a warm, aqueous sodium hydroxide solution, NaOH.

(i) State the equation for the reaction of C_4H_9Br with NaOH. *[1]*

(ii) Suggest what would happen to the pH of the solution as the reaction proceeds. *[1]*

(c) The time taken to produce a certain amount of product using different initial concentrations of C_4H_9Br and NaOH is measured. The results are shown in the following table.

Reaction	$[C_4H_9Br]$ / 10^{-3} mol dm^{-3}	[NaOH] / 10^{-3} mol dm^{-3}	t / s
A	1.0	2.0	46
B	2.0	2.0	23
C	2.0	4.0	23

(i) Deduce the effect of the concentration of C_4H_9Br and NaOH on the rate of reaction. *[2]*

C_4H_9Br:

NaOH:

(ii) Suggest why **warm** sodium hydroxide solution is used. *[1]*

(iii) Deduce whether C_4H_9Br is a primary or tertiary halogenoalkane. *[2]*

(iv) Determine the structural formula of C_4H_9Br. *[1]*

(v) Describe, using an equation, how C_4H_9Br can be converted into $C_4H_8Br_2$. *[1]*

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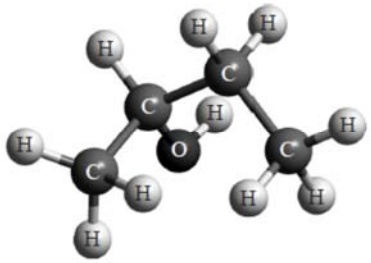
Q# 7/ IB Chem/2013/s/TZ1/Paper 2 Section A/Standard Level/

5. The following diagram shows the three-dimensional structure of a molecule.



(a) Apply IUPAC rules to state the name of this molecule. *[1]*

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. . . . . .

(b) Deduce the structural formula of **two** isomers of the molecule above with the same functional group. *[2]*

(c) Describe, using an equation, the oxidation by acidified potassium dichromate(VI) of the substance shown in the diagram. Use the symbol [O] to represent the oxidizing agent. *[1]*

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. . . . . .

Q# 8/ IB Chem/2012sQ2

(b) The combustion of unleaded gasoline still produces pollution with both local and global consequences. Identify **one** exhaust gas which causes local pollution and **one** exhaust gas which causes global pollution. *[2]*

Local pollutant:

. . . . . .

Global pollutant:

. . . . . .

6. Alkenes, alcohols and esters are three families of organic compounds with many commercial uses.

(a) (i) State **two** industrial uses of ethene. *[2]*

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(ii) State the meaning of the term *structural isomers*. *[1]*

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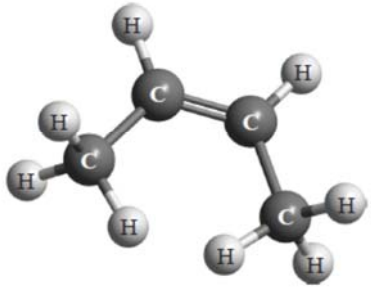
(iii) **X** is an isomer of C_4H_8 and has the structural formula shown below.



Apply IUPAC rules to name this isomer. Deduce the structural formulas of **two** other isomers of C_4H_8. *[3]*

.....

(iv) State the balanced chemical equation for the reaction of **X** with HBr to form **Y**. *[1]*

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.....

(v) **Y** reacts with aqueous sodium hydroxide, NaOH(aq), to form an alcohol, **Z**. Identify whether **Z** is a primary, secondary or tertiary alcohol. *[1]*

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(vii) Deduce the structural formula of the organic product formed when **Z** is oxidized by heating under reflux with acidified potassium dichromate(VI) **and** state the name of the functional group of this organic product. *[2]*

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(b) Esters are often used in perfumes. Analysis of a compound containing the ester functional group only, gives a percentage composition by mass of C: 62.0% and H: 10.4%.

(i) Draw the ester functional group. *[1]*

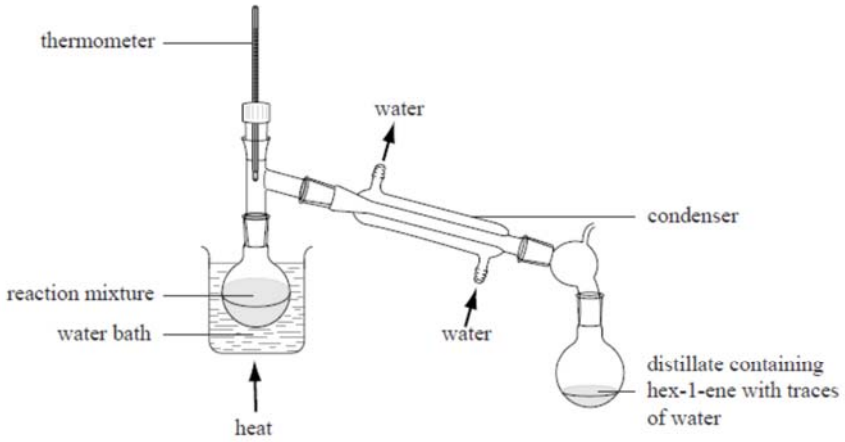
(ii) Determine the empirical formula of the ester, showing your working. *[4]*

(iii) The molar mass of the ester is 116.18 g mol^{-1}. Determine its molecular formula. *[1]*

7. A student prepared hex-1-ene, C_6H_{12}, from hexan-1-ol, $C_6H_{13}OH$, by a dehydration reaction.

$$C_6H_{13}OH(l) \rightarrow C_6H_{12}(l) + H_2O(l)$$

The apparatus for this preparation is shown below. The reaction mixture contains 5.00 g of hexan-1-ol and an excess of concentrated sulfuric acid, which removes the water from the organic compound.



The distillate was dried to obtain 2.62 g of hex-1-ene.

(a) (i) Determine the amount, in mol, of hexan-1-ol present in the reaction mixture. *[2]*

(ii) Calculate the percentage yield of hex-1-ene produced. *[2]*

(iii) Another student repeated the experiment and reported a yield of 5.24 g of organic product. Comment on this result. *[2]*

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(b) Hex-1-ene can be converted to hexane in a single step.

(i) State the reagent and conditions needed and draw the structural formula of the product. *[2]*

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(ii) Deduce the names of three isomers of hexane. *[3]*

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(iii) Identify the compound with the molecular formula C_6H_{14} which has the highest boiling point and explain your choice. *[3]*

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(iv) The conversion of carbon-carbon double bonds to carbon-carbon single bonds is an important stage in the synthesis of a commercial product. Identify this commercial product. *[1]*

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(c) (i) Hexane reacts with chlorine to form different products. The reactions can be represented by the following equation, where R is an alkyl chain.

$$R\text{–}H + Cl_2 \rightarrow R\text{–}Cl + HCl$$

Describe the stepwise mechanism by giving **one** equation for each step and state the essential condition in the initiation step. *[4]*

Initiation:

.....

Essential condition:

.....

Propagation:

.....

Termination:

.....

(ii) Deduce the number of straight-chain structural isomers produced with the molecular formula $C_6H_{13}Cl$. *[1]*

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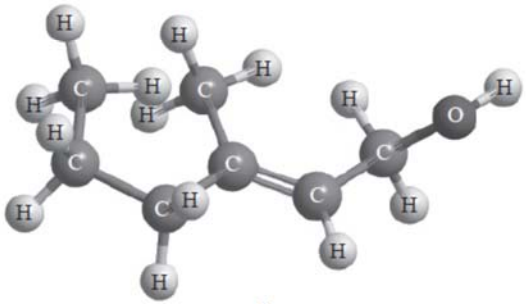
Q# 11/ IB Chem/2012/s/TZ1/Paper 2 Section A/Standard Level/

3. Compound **X** (shown below) is produced by bacteria living in human armpits and is thought to be partly responsible for unpleasant body smells.

(a) Bromine water can be used to test for the presence of one of the functional groups in **X**. Identify this functional group and describe the colour change observed. *[2]*



X

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(b) The other functional group changes when **X** is refluxed with acidified excess potassium dichromate(VI) to produce a compound **Y**.

(i) Identify the functional group present in **Y** but not in **X**. *[1]*

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.....

(ii) State the type of reaction that **X** undergoes to form **Y**. *[1]*

.....
.....

(c) A different compound is produced if excess **X** is heated with acidified potassium dichromate(VI) and the product **Z** is distilled off as it forms.

(i) Identify the functional group present in **Z** but not in **X**. *[1]*

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(ii) Predict the order of increasing boiling point of the compounds **X**, **Y** and **Z** and explain your answer. *[3]*

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Q# 12/ IB Chem/2011wQ4

(d) Based on the types of intermolecular force present, explain why butan-1-ol has a higher boiling point than butanal. *[2]*

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7. (a) One example of a homologous series is the alcohols. Describe **two** features of a homologous series. *[2]*

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(b) Consider the following reactions.

$(CH_3)_2CH(CH_2)_3OH$ (**X**) $\longrightarrow$ $(CH_3)_2CH(CH_2)_2CHO$ (**Y**)

$\downarrow$

$(CH_3)_2CH(CH_2)_2COOH$ (**Z**)

(i) The IUPAC name of **X** is 4-methylpentan-1-ol. State the IUPAC names of **Y** and **Z**. *[2]*

Y: .....

Z: .....

(ii) State the reagents and reaction conditions used to convert **X** to **Y** and **X** to **Z**. *[2]*

X to **Y**: .....
.....

X to **Z**: .....
.....

(iv) Discuss the volatility of **Y** compared to **Z**. *[2]*

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6. Alkenes are important starting materials for a variety of products.

(a) State and explain the trend of the boiling points of the first five members of the alkene homologous series. *[3]*

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(b) Describe **two** features of a homologous series. *[2]*

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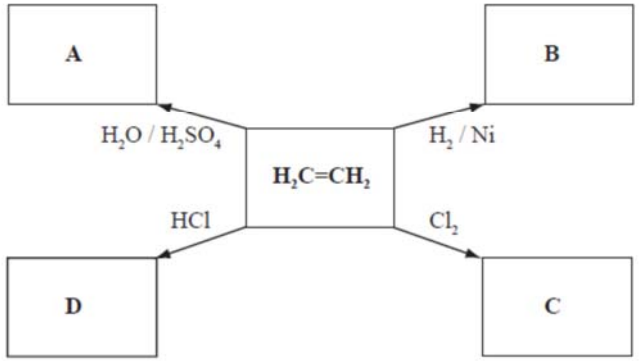
(c) Below is a schematic diagram representing some reactions of ethene. The letters **A–D** represent the organic compounds formed from the reactants and catalysts shown.



Deduce the structural formulas of compounds **A**, **B**, **C**, and **D** and state the IUPAC name of compound **C**. *[5]*

A:

B:

C:

IUPAC name: .....

D:

(d) Describe a chemical test that could be used to distinguish between pent-1-ene and pentane. *[2]*

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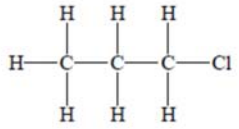
(e) State and explain whether the following molecules are primary, secondary or tertiary halogenoalkanes. *[4]*

E:



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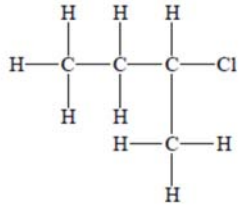
F:



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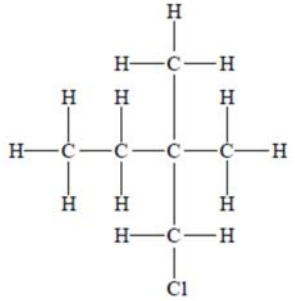
G:



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(f) Explain, using equations, the following steps in the free-radical mechanism of the reaction of methane with chlorine. *[4]*

- Initiation
- Propagation
- Termination

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Q# 15/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q4

(e) State the name of the product and identify the type of reaction which occurs between ethene and hydrogen chloride. *[2]*

Q# 16/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/

5. Consider the following sequence of reactions.

$$RCH_3 \xrightarrow{reaction\ 1} RCH_2Br \xrightarrow{reaction\ 2} RCH_2OH \xrightarrow{reaction\ 3} RCOOH$$

RCH_3 is an unknown alkane in which R represents an alkyl group.

(a) The alkane contains 81.7 % by mass of carbon. Determine its empirical formula, showing your working. *[3]*

(b) Equal volumes of carbon dioxide and the unknown alkane are found to have the same mass, measured to an accuracy of two significant figures, at the same temperature and pressure. Deduce the molecular formula of the alkane. *[1]*

(c) (i) State the reagent and conditions needed for *reaction 1*. *[2]*

(ii) State the reagent(s) and conditions needed for *reaction 3*. *[2]*

(d) *Reaction 1* involves a free-radical mechanism. Describe the stepwise mechanism, by giving equations to represent the initiation, propagation and termination steps. *[4]*

(f) Propan-1-ol has two structural isomers.

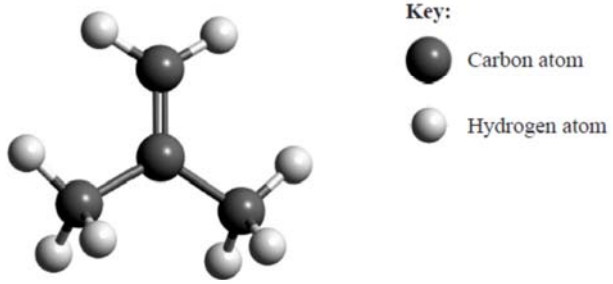
(i) Deduce the structural formula of each isomer. *[2]*

(ii) Identify the isomer from part (f) (i) which has the higher boiling point and explain your choice. Refer to both isomers in your explanation. *[2]*

Q# 17/ IB Chem/2010/w/TZ0/Paper 2 Section A/Standard Level/

2. The alkenes are an example of a homologous series.

(a) State the name of the alkene shown. *[1]*



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(b) Bromine water, $Br_2(aq)$, can be used to distinguish between the alkanes and the alkenes.

(i) Describe the colour change observed when the alkene shown in part (a) is added to bromine water. *[1]*

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(ii) Draw the structural formula and state the name of the product formed. *[2]*

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(c) The polymerization of the alkenes is one of the most significant reactions of the twentieth century.

(i) Outline **two** reasons why the polymers of the alkenes are of economic importance. *[2]*

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(ii) State the type of polymerization reaction shown by the alkene in part (a). *[1]*

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(iii) Deduce the structure of the resulting polymer showing **three** repeating units. *[1]*

(iv) Explain why monomers are often gases or volatile liquids, but polymers are solids. *[2]*

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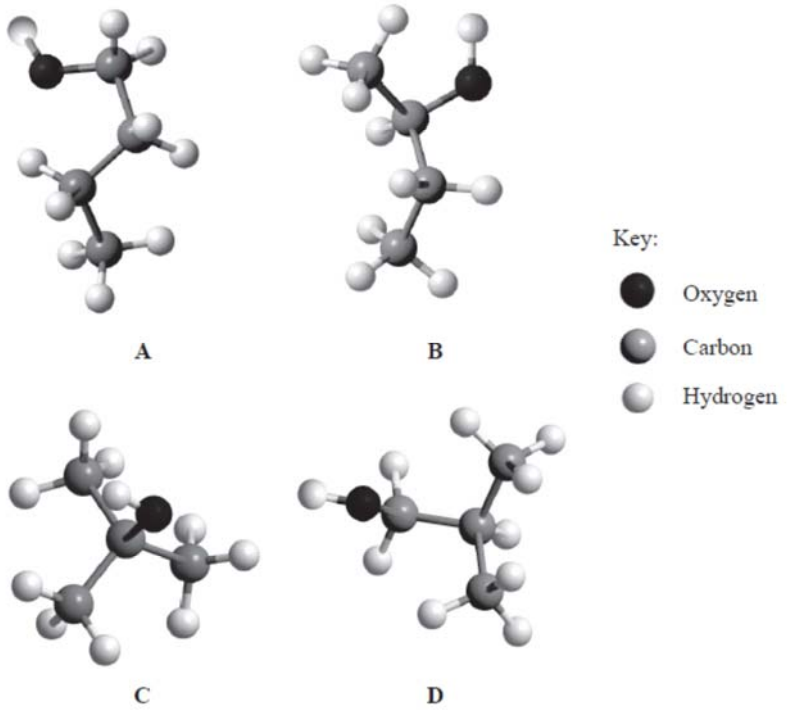
Q# 18/ IB Chem/2010/s/tz1/Paper 2 Section B/Standard Level/q6

(b) Ethanol is part of the homologous series of alcohols. Describe **two** features of a homologous series. *[2]*

(c) (i) Below are **four structural** isomers of alcohols with molecular formula $C_4H_{10}O$. State the name of each of the isomers **A**, **B**, **C** and **D**. *[4]*



(ii) Determine the isomer that cannot be oxidized by acidified potassium dichromate(VI), $K_2Cr_2O_7$. *[1]*

(iii) Determine the isomer which can be oxidized to butanal. *[1]*

(iv) Determine the isomer which can be oxidized to butanone. *[1]*

(v) Suggest the structural formula of another isomer of $C_4H_{10}O$. *[1]*

Q# 19/ IB Chem/2010/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) Chloroethene, C_2H_3Cl, is an important organic compound used to manufacture the polymer poly(chloroethene).

(i) Draw the Lewis structure for chloroethene and predict the H–C–Cl bond angle. *[2]*

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(ii) Draw a section of poly(chloroethene) containing six carbon atoms. *[1]*

(iii) Outline why the polymerization of alkenes is of economic importance and why the disposal of plastics is a problem. *[2]*

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(b) (i) Chloroethene can be converted to ethanol in two steps. For each step deduce an overall equation for the reaction taking place. *[2]*

Step 1:

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Step 2:

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(ii) State the reagents and conditions necessary to prepare ethanoic acid from ethanol in the laboratory. *[2]*

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Q# 20/ IB Chem/2009/w/tz0/Paper 2 Section B/Standard Level/

7. (a) Halogenoalkanes can undergo substitution reactions with potassium hydroxide solution.

(i) State an equation for the reaction of C_4H_9Cl with KOH. *[1]*

(b) (i) Draw four structural isomers of molecular formula $C_4H_{10}O$ which contain the –OH group. *[4]*

(ii) On reaction with acidified potassium dichromate(VII), two of the isomers are oxidised in two steps to produce different products. Draw the structural formula of the **two** products formed from one of the isomers. *[2]*

(iii) A third isomer is oxidized in one step. Draw the structural formula of the organic product formed. *[1]*

(iv) State the colour change that takes place in these oxidation reactions. *[1]*

(v) Identify the isomer which resists oxidation by acidified potassium dichromate(VI). *[1]*

Q# 21/ IB Chem/2009/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) The boiling points of the isomers of pentane, C_5H_{12}, shown are 10, 28 and 36 °C, but not necessarily in that order.

A **B** **C**

(i) Identify the boiling points for each of the isomers **A**, **B** and **C** and state a reason for your answer. *[3]*

Isomer	A	B	C
Boiling point			

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(ii) State the IUPAC names of isomers **B** and **C**. *[2]*

B: .....

C: .....

(b) Both C_5H_{12} and $C_5H_{11}OH$ can be used as fuels. Predict which compound would release a greater amount of heat per gram when it undergoes complete combustion. Suggest **two** reasons to support your prediction. *[3]*

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(c) In many cities around the world, public transport vehicles use diesel, a liquid hydrocarbon fuel, which often contains sulfur impurities and undergoes incomplete combustion. All public transport vehicles in New Delhi, India, have been converted to use compressed natural gas (CNG) as fuel. Suggest **two** ways in which this improves air quality, giving a reason for your answer. *[3]*

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Q# 22/ IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/

7. (a) Three compounds with similar relative molecular masses are butane, propanal and propan-1-ol.

(i) List the three compounds in order of increasing boiling point (lowest first) and explain the differences in their boiling points. *[4]*

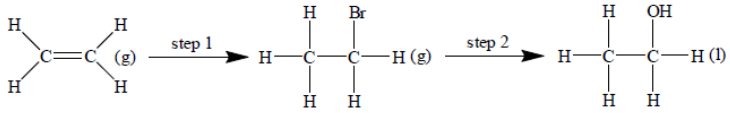
(ii) Predict, with an explanation, which of the three compounds is **least** soluble or miscible in water. *[2]*

(iii) When propan-1-ol is oxidized using a warm acidified solution of potassium dichromate(VI) two different organic products can be obtained. Deduce the name and structural formula for each of these two products. *[3]*

(iv) Propan-2-ol is an isomer of propan-1-ol. Draw the structure of propan-2-ol. *[1]*

(v) Identify the class of alcohols that propan-2-ol belongs to and state the name of the organic product formed when it is oxidized by an acidified solution of potassium dichromate(VI). *[2]*

(b) Ethanol can be formed from ethene in a two step reaction:

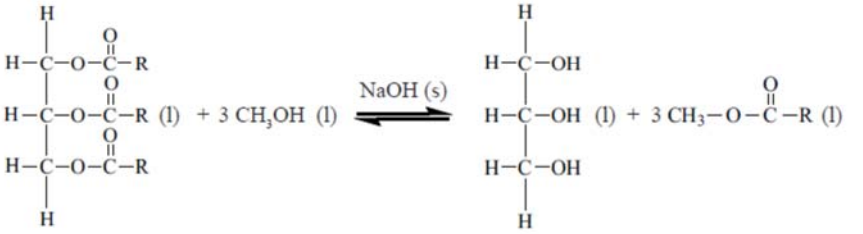


(i) State the name of the reagent used for step 1. *[1]*

(ii) State the name of the reagent and the conditions used for step 2. *[2]*

Q# 23/ IB Chem/2009/s/TZ1/Paper 2 Section A/Standard Level/

1. Biodiesel makes use of plants' ability to fix atmospheric carbon by photosynthesis. Many companies and individuals are now using biodiesel as a fuel in order to reduce their carbon footprint. Biodiesel can be synthesized from vegetable oil according to the following reaction.



vegetable oil methanol glycerol biodiesel

(a) Identify the organic functional group present in both vegetable oil and biodiesel. *[1]*

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(b) For part of her extended essay investigation into the efficiency of the process, a student reacted a pure sample of a vegetable oil (where $R=C_{17}H_{33}$) with methanol. The raw data recorded for the reaction is below.

Mass of oil	= 1013.0 g
Mass of methanol	= 200.0 g
Mass of sodium hydroxide	= 3.5 g
Mass of biodiesel produced	= 811.0 g

The relative molecular mass of the oil used by the student is 885.6. Calculate the amount (in moles) of the oil and the methanol used, and hence the amount (in moles) of excess methanol. *[3]*

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(d) The reactants had to be stirred vigorously because they formed two distinct layers in the reaction vessel. Explain why they form two distinct layers and why stirring increases the rate of reaction. *[2]*

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(e) Calculate the percentage yield of biodiesel obtained in this process. *[2]*

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(f) When biodiesel is combusted it produces carbon dioxide. Explain why the use of biodiesel as a fuel does not significantly contribute to global warming. *[1]*

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Q# 24/ IB Chem/2008/w/tz0/Paper 2 Section B/Standard Level/

6. Several **straight-chain** organic compounds have the molecular formula $C_4H_8O_2$. Compound **A** is acidic but compounds **B**, **C** and **D** are neutral liquids with characteristic smells. None of the compounds contain C=C bonds.

(a) (i) Deduce the empirical formula for these compounds. *[1]*

(ii) Deduce the structural formula and name of compound **A**. *[2]*

(b) (i) Compound **A** can be prepared by the oxidation of butan-1-ol. Identify the reagents used for the oxidation. Predict the name of the organic compound that can be formed when butan-1-ol is partially oxidized. Suggest how the reaction can be controlled to give a low yield of this compound formed by partial oxidation and a high yield of compound **A**. *[4]*

(iii) Draw the structural formulas of compounds **C** and **D**. *[2]*

(iv) Predict, with reference to the intermolecular forces in each case, which of the compounds **A** and **B** has the higher boiling point. *[2]*

Q# 25/ IB Chem/2008/s/tz1/Paper 2 Section B/Standard Level/q8

(c) The sequence shows some reactions of organic compounds.

$$\underset{\text{A}}{C_3H_8O} \xrightarrow{K_2Cr_2O_7/H^+} \underset{\text{B}}{C_3H_6O} \xrightarrow{K_2Cr_2O_7/H^+} \underset{\text{C}}{C_3H_6O_2}$$

(i) Describe the colour change that occurs when $K_2Cr_2O_7$ acts as an oxidizing agent. *[1]*

(ii) Deduce the names of compounds **A**, **B** and **C**. *[3]*

(iii) Compound **A** reacts with ethanoic acid to form compound **D** with molecular formula $C_5H_{10}O_2$. State the type of reaction occurring and deduce the name of compound **D**. *[2]*

(iv) Explain, with reference to the intermolecular forces present, why compound **A** has a higher boiling point than compound **B**. *[2]*

Q# 26/ IB Chem/2008/s/TZ1/Paper 2 Section A/Standard Level/

5. (a) The compound C_3H_6 reacts with bromine. Write an equation and state an observation for this reaction. *[2]*

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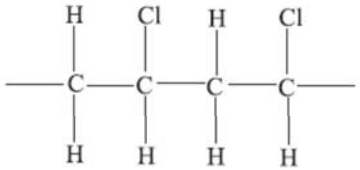
(c) Suggest the type of polymerization reaction that C_3H_6 undergoes and draw the structure of a section of the polymer chain formed from three monomer molecules. *[2]*

Type of polymerization .....

Q# 27/ IB Chem/2007/w/tz0/Paper 2 Section B/Standard Level/q5c

(iii) A section of a polymer is shown below:



Draw the structural formula and state the name of the monomer used to make this polymer. *[2]*

Q# 28/ IB Chem/2007/w/tz0/Paper 2 Section B/Standard Level/

5. (a) The reaction between ethene and hydrogen gas is exothermic.

(i) Write an equation for this reaction. *[1]*

Q# 29/ IB Chem/2007/s/tz1/Paper 2 Section B/Standard Level/

5. Ethene is an unsaturated hydrocarbon used as a starting material for many organic chemicals.

(a) Draw the structural formula of ethene and state the meaning of the term *unsaturated hydrocarbon*. *[2]*

(b) State an equation for the conversion of ethene to ethanol and identify the type of reaction. *[2]*

(c) Describe the complete oxidation of ethanol and name the product. Include the conditions, reagents required and any colour changes. *[4]*

(d) State an equation for the reaction between ethanol and the product of complete oxidation in (c). Include any other reagent required for this reaction. Name the organic product and state **one** possible use of this product. *[4]*

(e) Explain why ethene undergoes addition polymerisation but not condensation polymerisation. [2]

(f) (i) State the meaning of the term *isomers*. [1]

(ii) Draw the functional group isomers of C_3H_6O. [2]

Q# 30/ IB Chem/2006/w/tz0/Paper 2 Section B/Standard Level/

5. (a) Butane, C_4H_{10}, and but-2-ene, C_4H_8, are both colourless gases at 70 °C.

(i) Write an equation for the complete combustion of but-2-ene. [1]

(ii) Describe a chemical test, and its result, to distinguish but-2-ene from butane. [2]

(b) CH_3COCH_3 is the first member of the ketone homologous series. Draw the full structural formula of the next member of this homologous series and predict how its melting point compares with that of CH_3COCH_3. [2]

Q# 31/ IB Chem/2006/s/tz1/Paper 2 Section B/Standard Level/q8

(e) Given the structures of the repeating units of the polymers below, identify the monomers from which they are formed.

(i) $-(-CH_2-CH_2-)-$ [1]

(g) Many organic compounds can exist as isomers. Draw and name an isomer of ethanoic acid, CH_3COOH. [2]

Q# 32/ IB Chem/2006/s/tz1/Paper 2 Section B/Standard Level/q7

(c) (i) Draw a Lewis structure of a water molecule, name the shape of the molecule and state and explain why the bond angle is less than the bond angle in a tetrahedral molecule such as methane. [4]

(ii) Explain why water is a suitable solvent for ethanol, but not for ethane. [2]

(d) Predict and explain the order of the melting point for propanol, butane and propanone with reference to their intermolecular forces. [4]

Q# 33/ IB Chem/2005wQ1

(d) Another organic compound, **B**, has the formula $CH_3CH_2CH(CH_3)COOH$.

(i) State the name of the compound. [1]

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Q# 34/ IB Chem/2005sQ2

(c) Explain why the **incomplete** combustion of hydrocarbons is harmful to humans. [2]

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Q# 35/ IB Chem/2005/w/tz0/Paper 2 Section B/Standard Level/

7. Ethene, propene and but-2-ene are members of the alkene homologous series.

(a) Describe **three** features of members of a homologous series. [3]

(b) State and explain which compound has the highest boiling point. [3]

(c) Draw the structural formula and give the name of an alkene containing five carbon atoms. [2]

(d) Write an equation for the reaction between but-2-ene and hydrogen bromide, showing the structure of the organic product. State the type of reaction occurring. [3]

(e) Propene can be converted to propanoic acid in three steps:

$$\text{propene} \xrightarrow{\text{step 1}} \text{propan-1-ol} \xrightarrow{\text{step 2}} \text{propanal} \xrightarrow{\text{step 3}} \text{propanoic acid}$$

State the type of reaction occurring in steps 2 and 3 and the reagents needed. Describe how the conditions of the reaction can be altered to obtain the maximum amount of propanal, and in a separate experiment, to obtain the maximum amount of propanoic acid. [5]

(f) Identify the strongest type of intermolecular force present in each of the compounds propan-1-ol, propanal and propanoic acid. List these compounds in decreasing order of boiling point. [4]

Q# 36/ IB Chem/2005/s/tz1/Paper 2 Section B/Standard Level/

8. Several compounds have the molecular formula $C_3H_6O_2$.
Three of them, **A**, **B** and **C**, have the following properties:

A is soluble in water and is acidic

B and **C** are neutral and do not react with bromine.

(a) Give a structural formula for each of these compounds and name them. [6]

(b) (i) Explain the solubility and acidity of **A** in water. [2]

(ii) Write an equation for the reaction of **A** with sodium hydroxide solution. [1]

(iii) Explain why **B** and **C** do not react with bromine. [1]

(c) State and explain which one of **A**, **B** or **C** has the highest boiling point. [2]

(d) (i) Name the class of compounds to which **B** and **C** belong and state a use of this class of compounds. [2]

(ii) Name the **two** classes of compounds used to form **B** or **C**, and state the other product formed in this reaction. [3]

(e) Suggest the structural formula of an isomer of $C_3H_6O_2$ which does react rapidly with bromine. Name this type of reaction, and describe an observation that can be made during the reaction. [3]

Q# 37/ IB Chem/2005/s/TZ1/Paper 2 Section A/Standard Level/

5. Give the structural formulas for the isomers of molecular formula C_4H_{10} and state the name of each one. *[4]*

Q# 38/ IB Chem/2004wQ3

(c) Explain why no reaction takes place between methane and chlorine at room temperature unless the reactants are sparked, exposed to UV light or heated. *[2]*

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Q# 39/ IB Chem/2004/w/tz0/Paper 2 Section B/Standard Level/

5. (a) The plastic PVC, poly(chloroethene), is made from the monomer chloroethene, C_2H_3Cl, by a polymerization reaction.

(i) Draw the structural formula of chloroethene. *[1]*

(ii) State the type of polymerization reaction that occurs to make poly(chloroethene) and identify the structural feature needed in the monomer. *[2]*

(iii) Draw the structure of the repeating unit of poly(chloroethene). *[1]*

(iv) Explain why monomers are often gases or volatile liquids, whereas polymers are solids. *[2]*

Q# 40/ IB Chem/2004/w/TZ0/Paper 2 Section A/Standard Level/

2. The alkanes are a *homologous series* of *saturated hydrocarbons*.

(a) State the meaning of each of the following terms.

(i) *homologous series* *[2]*

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(ii) *hydrocarbon* *[1]*

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(iii) *saturated* *[1]*

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(b) (i) State and explain the trend in the boiling points of the first five alkanes. *[2]*

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(ii) Explain why the enthalpies of combustion of alkanes are negative values. *[1]*

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(c) State the products of the complete combustion of alkanes. *[2]*

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Q# 41/ IB Chem/2004/s/tz1/Paper 2 Section B/Standard Level/

7. The compound C_2H_4 can be used as a starting material for the preparation of many substances.

(a) Name the compound C_2H_4 and draw its structural formula. *[2]*

(b) In the scheme below, state the type of reaction and identify the reagent needed for each reaction.

$$C_2H_4 \xrightarrow{\mathbf{A}} CH_3CH_2OH \xrightarrow{\mathbf{B}} CH_3COOH$$ *[4]*

(c) C_2H_4 can be converted into one of the compounds below in a single step reaction.

C_2H_3Cl $C_2H_4Cl_2$

Draw the structural formula for each of these compounds and identify the compound which can be formed directly from C_2H_4. *[3]*

(d) One of the two compounds in (c) has an isomer. Draw the structural formula of the isomer and explain why it can not be formed directly from C_2H_4. *[2]*

(e) C_2H_4 can also react to form a polymer. Name this **type** of polymer and draw the structural formula of a section of this polymer consisting of three repeating units. *[2]*

Q# 42/ IB Chem/2003/w/tz0/Paper 2 Section B/Standard Level/

7. (a) (i) List **three** characteristics of an homologous series, and explain the term *functional group*. *[3]*

(ii) Ethanol and ethanoic acid can be distinguished by their melting points. State and explain which of the two compounds will have a higher melting point. *[2]*

(c) For the two compounds $HCOOCH_2CH_3$ (I) and $HCOOCHCH_2$ (II):

(i) State and explain which of the two compounds can react readily with bromine. *[2]*

(ii) Compound II can form polymers. State the type of polymerization compound II undergoes, and draw the structure of the repeating unit of the polymer. *[2]*

Q# 43/ IB Chem/2003/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) Draw the Lewis structure of methanoic acid, HCOOH. *[1]*

(b) In methanoic acid, predict the bond angle around the *[2]*

(i) carbon atom. .....

(ii) oxygen atom bonded to the hydrogen atom. .....

(c) State and explain the relationship between the length and strength of the bonds between the carbon atom and the two oxygen atoms in methanoic acid. *[3]*

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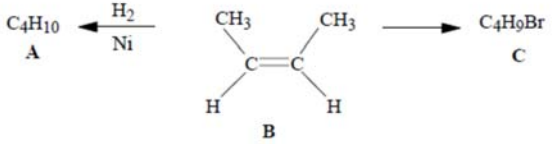
Q# 44/ IB Chem/2003/s/tz1/Paper 2 Section B/Standard Level/

8. Two reactions of an alkene, **B**, are shown below.



(a) (i) State the name of **A** and write an equation for its complete combustion. Explain why the incomplete combustion of **A** is dangerous. *[5]*

(ii) Outline a test to distinguish between **A** and **B**, stating the result in each case. *[3]*

(iii) Write an equation for the conversion of **B** to **C**. State the type of reaction taking place and draw the structure of **C**. *[3]*

(b) (i) A compound **D** has the molecular formula $C_2H_4O_2$ and is obtained from a reaction between methanoic acid and methanol. Write an equation for this reaction and state the name of **D**. *[3]*

(ii) A second compound, **E**, has the same molecular formula as **D** and has acidic properties. State the name of compound **E**. *[1]*

Q# 45/ IB Chem/2002/w/tz0/Paper 2 Section B/Standard Level/

6. Organic compounds are arranged as *homologous series* due to the presence of *functional groups*.

(a) Explain the meaning of the terms *homologous series* and *functional groups* using alkanols as examples. *[5]*

(d) Under certain conditions ethene can be converted to ethanol.

(i) Give a chemical test to identify ethene and state what would be observed.

(ii) Give a balanced equation for the reaction to form ethanol from ethene.

(iii) State the conditions necessary for the reaction in (d) (ii). *[4]*

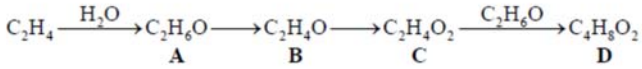
(e) Ethanol may be converted to ethanoic acid.

(i) Identify the reagent needed and state the type of reaction. *[2]*

(ii) State the colour change observed during the reaction. *[1]*

Q# 46/ IB Chem/2002/s/tz1/Paper 2 Section B/Standard Level/q4

4. This question is about four compounds **A**, **B**, **C** and **D**, which can be made from ethene by the following reactions. All four compounds are liquid at room temperature, and each compound's molecular formula is shown. Two of the reagents needed for the reactions are shown on the arrows.



(c) Identify the gas formed when **C** reacts with magnesium and write an equation for the reaction occurring. Name the other product of the reaction. *[3]*

(e) Compound **C** has another isomer. Name and give the structural formula of this isomer. *[2]*

Q# 47/ IB Chem/2001/w/TZ0/Paper 2 Section A/Standard Level/

2. Ethanol is used as a fuel because it undergoes combustion.

(a) Write a balanced chemical equation for the combustion of ethanol. *[2]*

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(b) The standard enthalpy of combustion, $\Delta H_c^\ominus$, and the relative molecular masses, M_r, of a series of alkanols are given below:

Alkanol	CH_3OH methanol	CH_3CH_2OH ethanol	$CH_3CH_2CH_2OH$ propan-1-ol	$CH_3CH_2CH_2CH_2OH$ butan-1-ol
$\Delta H_c^\ominus$ / kJ mol^{-1}	–715	–1371	–2010	–2673
M_r	32.0	46.0	60.0	74.0

(i) Calculate the relative molecular mass of pentan-1-ol and thus estimate $\Delta H_c^\ominus$ for pentan-1-ol using the graph below. *[2]*

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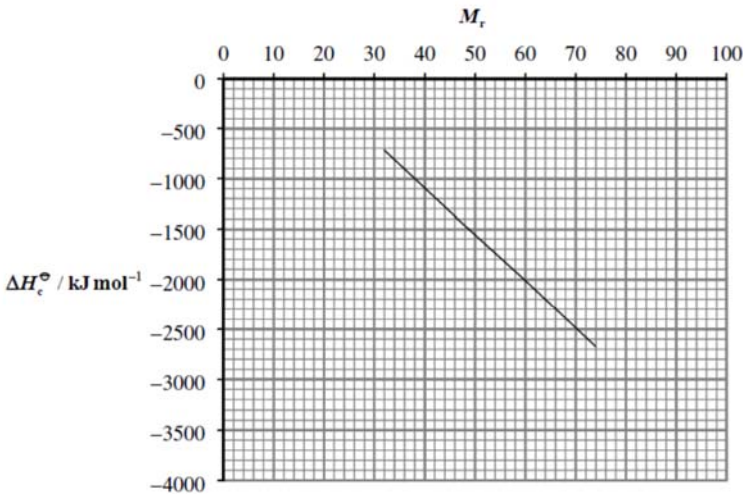

(ii) How would the value of the standard enthalpy of combustion of pentan-2-ol compare with that of pentan-1-ol? Explain your answer. *[2]*

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Q# 48/ IB Chem/2001/s/tz1/Paper 2 Section B/Standard Level/q6

(b) Explain at the molecular level why ethanol (C_2H_5OH) is soluble in water, but cholesterol ($C_{27}H_{45}OH$) and ethane (C_2H_6) are not. *[4]*

(c) Give an equation for the complete combustion of methane, CH_4. Identify **two** products formed by the incomplete combustion of methane and identify **one** harmful effect caused by **one** of the products. *[3]*

(d) Polyunsaturated oils contain many C=C bonds and react with hydrogen to yield fats. Using the simplified structure of an oil provided below, give the formula of the product formed by reacting this oil with *excess* hydrogen, **and** identify this type of reaction.

——C=C——C=C——C=C——C=C—— *[2]*

Q# 49/ IB Chem/2000/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) Write structural formulas and the names of the two alkanol isomers of C_3H_8O. *[2]*

Q# 50/ IB Chem/2000/s/tz1/Paper 2 Section B/Standard Level/

6. (a) Discuss the factors which affect the boiling points of covalently bonded compounds by reference to the following pairs of organic substances, whose boiling points are given:

- ethane (184 K) and butane (273 K);
- ethane (184 K) and bromoethane (311 K);
- bromoethane (311 K) and ethanol (352 K). *[8]*

(b) For each of the following conversions:

(i) ethene → poly(ethene)

identify the type of reaction, the reagent(s) needed, the condition(s) needed and the structural formula of the product.

[4]

Q# 51/ IB Chem/1999/w/tz0/Paper 2 Section B/Standard Level/

4. **(a)** **Ethanol can be oxidised first to ethanal then to ethanoic acid by warming with an acidified solution of potassium dichromate(VI).**

(i) **Describe the colour change that occurs during the reaction.** *[1]*

(ii) **Explain why the boiling points of ethanol and ethanoic acid are considerably higher than the boiling point of ethanal.** *[3]*

Q# 52/ IB Chem/1999/s/TZ1/Paper 2 Section A/Standard Level/

3. **(a)** **State and explain the trend in boiling points of the first 10 members of the alkene series.** *[3]*

. . . . . .

. . . . . .

. . . . . .

. . . . . .

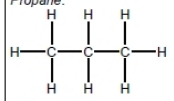
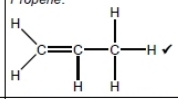
(b) **Explain why methanol has a much higher boiling point than ethane ($M_r = 30$).** *[2]*

. . . . . .

. . . . . .

Mark Scheme IB SL 10 EQ 16w to 99s P2 Section A & B 433marks

Q# 1/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q5

Question			Answers	Notes	Total
5.	a		*Propane*:  ***AND*** *Propene*:  ✓		1
5.	b	i	$C_3H_8 + Br_2 \rightarrow C_3H_7Br + HBr$ ✓ «sun»light/UV/*hν* ***OR*** high temperature ✓	*Do not accept "reflux" for M2.*	2
5.	b	ii	$C_3H_8 + Br_2 \rightarrow C_3H_6Br_2$ ✓		1
5.	b	iii	*Propane*: «free radical» substitution / S_R ***AND*** *Propene*: «electrophilic» addition / A_E ✓	*Award mark even if incorrect type of substitution/ addition given.*	1

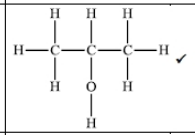
Q# 2/ IB Chem/2016/w/TZ0/Paper 2 Section A/Standard Level/Q1

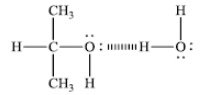
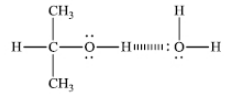
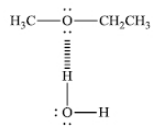
1.	d		acidified «potassium» dichromate«(VI)» / H^+ ***AND*** $K_2Cr_2O_7$ / H^+ ***AND*** $Cr_2O_7^{2-}$ ***OR*** «acidified potassium» manganate(VII) / «H^+» $KMnO_4$ / «H^+» MnO_4^- ✓	*Accept H_2SO_4 or H_3PO_4 for H^+.* *Accept "permanganate" for "manganate(VII)".*	1

Q# 3/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q4

4.	a		*I:* carboxamide ✓ *II:* phenyl ✓ *III:* carboxyl / carboxy ✓ *IV:* hydroxyl ✓	*Award [2] for all four correct, [1] for two or three correct.* *Do not allow benzene.* *Do not allow carboxylic/alkanoic acid.* *Do not allow alcohol or hydroxide.*	2 max

	b	iii	$(0.5)(40-20-2) = 9$ ✓		1
	b	iv	*A:* C–H **and** *B:* C=O		1
	b	v	O–H **and** N–H ✓ frequencies/stretches due to O–H and N–H occur above 3200 ‹cm^{-1}› which are not present in IR of *bute* ✓		2
	c	i	1:1:6 ✓		1

Question			Answers	Notes	Total
	c	ii	 ✓		1
	c	iii	$CH_3OCH_2CH_3$ ✓		1
	c	iv	*Similarity:* both have fragment corresponding to $(M_r - 15)^+$ / both have $m/z = 45$ ✓ *Difference:* **X** has fragment corresponding to $(M_r - 17)^+$ / **X** has $m/z = 43$ ***OR*** **X** has fragment corresponding to $(M_r - 43)^+$ / **X** has $m/z = 17$ ***OR*** **Y** has fragment corresponding to $(M_r - 31)^+$ / **Y** has $m/z = 29$ ***OR*** **Y** has fragment corresponding to $(M_r - 29)^+$ / **Y** has $m/z = 31$ ✓	*Allow both have same molecular ion peak/M^+ / both have m/z = 60. However in practice the molecular ion peak is of low abundance and difficult to observe for propan-2-ol.*	2

Question			Answers	Notes	Total
4.	c	v	both **X** and **Y** will exhibit hydrogen bonding with water molecules ✓ diagrams showing hydrogen bonding ✓ X:  **OR**  Y: 		2
	c	vi	*I:* CH_3COCH_3 ✓ *II:* $CH_3COOCH(CH_3)_2$ ✓		2
	c	vii	propanone ✓		1

Q# 4/ IB Chem/2016/SP/TZ0/Paper 2 Section A/Standard Level/Q2

Question			Answers	Notes	Total
2.	a	i	radical / unpaired electron ✓		1

Q# 5/ IB Chem/2016/s/TZ0/Paper 2 Section A/Standard Level/Q4

Question			Answers	Notes	Total
4.	a	i	methylpropene ✓		1
4.	a	ii	$-CH_2-C(CH_3)_2-CH_2-C(CH_3)_2-CH_2-C(CH_3)_2-$ ✓	*Must have continuation bonds at both ends.* *Accept any orientation of the monomers, which could give methyl side-chains on neighbouring atoms etc.*	1

4.	a	iii	$C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l)$ ✓		1
4.	b	i	«structural/functional group» isomer«s» ✓		1
4.	b	ii	*Test:* «react with» bromine/Br_2 «in the dark» *OR* «react with» bromine water/Br_2(aq) «in the dark» ✓ *A*: from yellow/orange/brown to colourless ***AND*** *B*: colour remains/slowly decolourized ✓	*Accept other correct reagents, such as manganate(VII) or iodine solutions, and descriptions of the corresponding changes observed.* *Accept "decolourized" for A and "not decolourized/unchanged" for B.* *Do **not** accept "clear/transparent" instead of "colourless".*	2

Q# 6/ IB Chem/2013/s/tz1/Paper 2 Section B/Standard Level/

8. (a) (i) same functional group / same general formula;
difference between successive members is CH_2;
similar chemical properties;
Do not accept "same" chemical properties.

gradually changing physical properties; ***[3 max]***

(ii) adding bromine (water);
ethene: brown/orange to colourless / decolourizes bromine water **and**
ethane: does not change colour; ***[2]***

OR

adding acidified potassium permanganate solution/$KMnO_4$(aq);
ethene: purple to colourless/brown **and**
ethane: does not change colour;

OR

adding Baeyer's reagent;
ethene: purple/pink to brown **and**
ethane: does not change colour;

Do not accept "clear" or "transparent" for "colourless".

(iii) $C_2H_4 + HBr \rightarrow C_2H_5Br$;
$C_2H_6 + Br_2 \rightarrow C_2H_5Br + HBr$; ***[2]***
Accept structural formulas.
Penalise missing H atoms or incorrect bonds (such as C–HO, C–H_2C) in structural formulas only once in the paper.

(b) (i) $C_4H_9Br + OH^- \rightarrow C_4H_9OH + Br^-$; ***[1]***
Accept NaOH in the equation.

(ii) decreases; ***[1]***

(c) (i) *C_4H_9Br:*
[C_4H_9Br] doubles **and** time halves/rate doubles / rate proportional to [C_4H_9Br];
Do not accept rate increases when [C_4H_9Br] increases.

NaOH:
[NaOH] doubles **and** time/rate does not change / rate independent of [NaOH]; ***[2]***

(ii) increases rate; ***[1]***
Accept increases number of collisions.

(iii) rate depends on [C_4H_9Br] only / rate does not depend on [OH^-] / S_N1 reaction / first order reaction / if it was primary, reaction would be S_N2;
tertiary; ***[2]***
Accept ECF.

(iv) $(CH_3)_3CBr$; ***[1]***
Allow both condensed and full structural formula.
Accept ECF.

(v) $C_4H_9Br + Br_2 \rightarrow C_4H_8Br_2 + HBr$; ***[1]***

Q# 7/ IB Chem/2013/s/TZ1/Paper 2 Section A/Standard Level/

5. (a) butan-2-ol/2-butanol; ***[1]***

(b) $CH_3CH_2CH_2CH_2OH$;
$(CH_3)_2CHCH_2OH$;
$(CH_3)_3COH$; ***[2 max]***
Accept condensed or full structural formulas.
Penalise missing H atoms or incorrect bonds (such as C–HO, C–H_2C) only once in the whole paper.

(c) $C_2H_5CHOHCH_3 + [O] \rightarrow C_2H_5COCH_3 + H_2O$; ***[1]***
Accept condensed or full structural formulas.
Accept [O] on top of the arrow.
Do not accept equation without H_2O.
Do not accept equation with $H^+/Cr_2O_7^{2-}$.

Q# 8/ IB Chem/2012sQ2

(b) *Local pollutant:*
carbon monoxide/CO / volatile organics/VOCs / nitrogen oxide/NO / (unburnt) hydrocarbons;
Do not accept methane/CH_4, ethane/C_2H_6, propane/C_3H_8 or butane/C_4H_{10}.

Global pollutant:
nitrogen oxide/NO / carbon dioxide/CO_2; ***[2]***
Accept nitrogen dioxide/NO_2 / NO_x for both local or global pollutant.
Accept other widely used names for NO such as nitric oxide/nitrogen monoxide/nitrogen(II) oxide or nitrogen(IV) oxide for NO_2.

Q# 9/ IB Chem/2012/w/tz0/Paper 2 Section B/Standard Level/

Penalize missing hydrogens or incorrect bonding (e.g. C–H_3C) once only in 6.

6. (a) (i) (hydration of ethane) to manufacture ethanol /$C_2H_4 + H_2O \rightarrow C_2H_5OH$;
synthesis of CH_3COOH/ethanoic acid;
Allow acetic acid instead of ethanoic acid.

synthesis of ethane-1,2-diol;
Allow 1,2-ethanediol/1,2 ethandiol/ethylene glycol/glycol alcohol instead of ethane-1,2-diol.

any appropriate polymerization of ethene; ***[2 max]***
e.g. polyethene, polychloroethene/PVC, polyphenylethene/polystyrene/PS etc.

Accept other industrial uses such as ripening of fruits.
Do not accept manufacture of margarine/alcohol/plastics/polymers/fuel.

(ii) compounds with the same molecular formula but different arrangement of atoms/structural formula/structures; ***[1]***
Do not allow similar instead of same.

(iii) (*cis*-)but-2-ene / (*Z*)but-2-ene / but-2-ene;
Accept (cis-)2-butene / Z-2-butene.
Ignore missing hyphens.

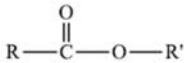
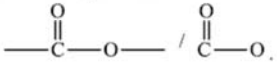
$CH_3CH_2CH{=}CH_2$;
$H_2C{=}C(CH_3)_2$; **[3]**
Accept either full or condensed structural formulas.
Allow structural formula of trans-but-2-ene.

(iv) $(CH_3)CH{=}CH(CH_3) + HBr \rightarrow CH_3CHBrCH_2CH_3$; **[1]**
Allow $C_4H_8 + HBr \rightarrow C_4H_9Br$.

(v) secondary/ 2°; **[1]**

(vii) $CH_3COCH_2CH_3$;
Full or condensed structural formula may be given.
*For primary **Z** from (v), accept $CH_3CH_2CH_2COOH/C_3H_7COOH$ but not $CH_3CH_2CH_2CHO$.*

ketone / alkanone; **[2]**

(b) (i) drawing of RCOOR' group /  **[1]**
Allow C instead of R or R'.
Allow  / .

(ii) $(100 - 62.0 - 10.4 =)\ 27.6\ \%\ O$;
$n_C : \left(\frac{62.0}{12.01} =\right) 5.162\ (mol)$ **and** $n_H : \left(\frac{10.4}{1.01} =\right) 10.297\ (mol)$
and $n_O : \left(\frac{27.6}{16.00} =\right) 1.725\ (mol)$;
dividing 5.162 and 10.297 by 1.725 (to get values $C_{2.992}H_{5.969}O_1$);
(empirical formula =) C_3H_6O; **[4]**
*Award **[4]** for correct final answer if alternative method used.*
Allow integer values for atomic masses (i.e. 12, 1 and 16).

(iii) $C_6H_{12}O_2$; **[1]**

Q# 10/ IB Chem/2012/s/tz1/Paper 2 Section B/Standard Level/

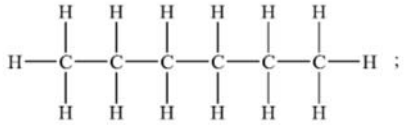
7. (a) (i) molar mass = 102.20 ($g\ mol^{-1}$);
amount $\left(= \frac{5.00}{102.20}\right) = 0.0489\ (mol)$; **[2]**

(ii) theoretical yield = $(84.18 \times 0.0489 =)\ 4.12\ (g)$;
percentage yield = $\left(\frac{2.62}{4.12} \times 100 =\right) 63.6\ \%$; **[2]**
Accept alternative calculation method.

(iii) yield above 100% not possible / experimental yield > theoretical yield / *OWTTE*;
Must have reference to a final yield.

sample contaminated with hexan-1-ol/water / inadequate drying / *OWTTE*; **[2]**
Do not accept error in reading balance/weighing scale.

(b) (i) hydrogen **and** Ni/Pd/Pt catalyst;



[2]
Allow condensed structural formula $CH_3(CH_2)_4CH_3$.

(ii) 2-methylpentane;
3-methylpentane;
2,2-dimethylbutane;
2,3-dimethylbutane; ***[3 max]***

(iii) hexane;
Accept the molecular structure, full structural formula or condensed structural formula.

straight chain/no branches, hence increased surface area/more closely packed;
stronger/larger/greater London/dispersion/van der Waals'; **[3]**
Accept the opposite arguments.
Do not accept stronger/larger/greater intermolecular forces.

(iv) margarine; **[1]**

(c) (i) *Initiation:*
$Cl_2 \rightarrow 2Cl\bullet$;

Essential condition:
UV/sunlight/*hf*/*hν* / heat;

Propagation:
$Cl\bullet + R{-}H \rightarrow HCl + R\bullet$ / $R\bullet + Cl_2 \rightarrow RCl + Cl\bullet$;

Termination:
$Cl\bullet + Cl\bullet \rightarrow Cl_2$ / $Cl\bullet + R\bullet \rightarrow RCl$ / $R\bullet + R\bullet \rightarrow R_2$; **[4]**
Allow more specific detail of R based on hexane (e.g. $CH_3(CH_2)_4CH_2{-}H$) in mechanistic steps.

(ii) three/3; **[1]**
If all three isomers are represented correctly award mark.

Q# 11/ IB Chem/2012/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) (carbon to carbon) double bond / alkene;
Accept if identified on diagram.

orange/brown/red/yellow to colourless / bromine is decolourized; *[2]*
M2 can be only scored if M1 correct.

(b) (i) $COOH/CO_2H$ / carboxylic acid / alkanoic acid; *[1]*
Do not allow carboxylic/alkanoic, carbonyl or carboxylate.

(ii) redox / oxidation (of alcohol); *[1]*

(c) (i) aldehyde / alkanal / CHO; *[1]*
Accept C=O / carbonyl.

(ii) **Z < X < Y**;
Accept Z,X,Y or ZXY.

no hydrogen bonding in **Z** / hydrogen bonding in **X and Y**;
*Accept statements such as **Z** has only van der Waals/London/dispersion forces **and** dipole-dipole forces.*

Y most polar / more electrons / forms dimers / forms two hydrogen bonds / greater molecular/molar mass; *[3]*
*Do not accept **Y** has a larger mass.*

Q# 12/ IB Chem/2011wQ4

(d) hydrogen bonding in butan-1-ol;
stronger than dipole-dipole attractions in butanal; *[2]*
Accept converse argument.
Do not penalize dipole-dipole bonding instead of dipole-dipole attractions.

Q# 13/ IB Chem/2011/w/tz0/Paper 2 Section B/Standard Level/

7. (a) same functional group;
successive/neighbouring members differ by CH_2;
same general formula;
similar chemical properties;
gradation in physical properties; *[2 max]*

(b) (i) **Y**: 4-methylpentanal;
Z: 4-methylpentanoic acid; *[2]*
Award [1] if student has correct endings for both molecules but has used incorrect stem.

(ii) *For both reactions reagents:*
named suitable acidified oxidizing agent;
Suitable oxidizing agents are potassium dichromate(VI)/$K_2Cr_2O_7$ / sodium dichromate(VI)/$Na_2Cr_2O_7$ / dichromate/$Cr_2O_7^{2-}$ / potassium manganate(VII)/ potassium permanganate/$KMnO_4$ / permanganate/manganate(VII)/MnO_4^-.
Accept H^+/H_2SO_4 instead of sulfuric acid and acidified.
Allow potassium dichromate or sodium dichromate (i.e. without (VI)) or potassium manganate (i.e. without (VII).

Conditions:
distillation for **X** to **Y and** reflux for **X** to **Z**; *[2]*
Award [1] if correct reagents and conditions identified for one process only.

(iii) acid partially dissociates/ionizes; *[1]*

(iv) **Y** more volatile than **Z**;
hydrogen bonding in carboxylic acid/**Z**; *[2]*
Accept converse argument.

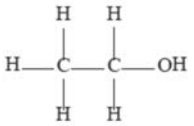
Q# 14/ IB Chem/2011/s/tz1/Paper 2 Section B/Standard Level/

6. (a) boiling points increase (from the first member to the fifth member);
increasing size of molecule/area of contact/number of electrons (from the first to the fifth member);
strength of intermolecular/van der Waals'/London/dispersion forces increase / more energy required to break the intermolecular bonds (from first member to fifth member); *[3]*

(b) same general formula;
successive members differ by CH_2;
same functional group / similar/same chemical properties;
gradual change in physical properties; *[2 max]*
Accept specific physical property such as melting point, boiling point only once.

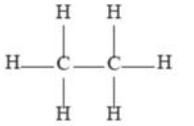
(c)

A:



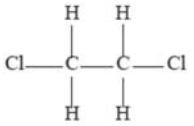
;

B:



;

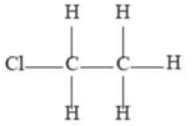
C:



;

1,2-dichloroethane;

D:



; *[5]*

Accept condensed formulas.
Penalize missing hydrogens only once.

(d) add bromine water/bromine;
pentane no change/stays brown **and** pent-1-ene decolourizes bromine water/bromine;

OR

add acidified $KMnO_4$;
pentane no change/stays purple **and** pent-1-ene decolourizes acidified $KMnO_4$; ***[2 max]***
Accept any correct colour change.
Do not accept 'clear' instead of 'colourless'.

(e) **E**: primary **and F**: secondary;
G: primary;
G / E: only one alkyl group/2 H atoms attached to the carbon atom attached to the Cl / only one carbon atom attached to the carbon atom attached to the Cl;
F: two alkyl groups/1 H atom attached to the carbon atom attached to the Cl / two carbon atoms attached to the carbon atom attached to the Cl; ***[4]***

(f) *Initiation:*
$Cl_2 \xrightarrow{UV/hf/hv/heat} 2Cl\bullet$;
Reference to UV/hf/hv/heat must be included.

Propagation:
$Cl\bullet + CH_4 \rightarrow CH_3\bullet + HCl$;
$CH_3\bullet + Cl_2 \rightarrow CH_3Cl + Cl\bullet$;

Termination:
$Cl\bullet + Cl\bullet \rightarrow Cl_2$ / $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$ / $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$; ***[4]***
Allow representation of radical without • (e.g. Cl, CH_3) if consistent throughout mechanism.
If representation of radical (i.e. •) is inconsistent, penalize once only.

Q# 15/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/q4

(e) chloroethane;
(electrophilic) addition; ***[2]***
Do not accept free radical/nucleophilic addition.

Q# 16/ IB Chem/2010/w/tz0/Paper 2 Section B/Standard Level/

5. (a) $n_C = \frac{81.7}{12.01} = 6.80$ **and** $n_H = \frac{18.3}{1.01} = 18.1$;
ratio of 1 : 2.67 / 1 : 2.7;
C_3H_8; ***[3]***
No penalty for using 12 and 1.

(b) C_3H_8; ***[1]***

(c) (i) Br_2/bromine;
UV/ultraviolet light; ***[2]***
Accept hf/hv/sunlight.

(ii) $Cr_2O_7^{2-}$ / MnO_4^- **and** acidified/ H^+/H_3O^+;
Accept names.
heat / reflux; ***[2]***

(d) *Initiation:*
$Br_2 \rightarrow 2Br\bullet$;

Propagation:
$Br\bullet + RCH_3 \rightarrow HBr + RCH_2\bullet$;
$RCH_2\bullet + Br_2 \rightarrow RCH_2Br + Br\bullet$;

*Termination: **[1 max]***
$Br\bullet + Br\bullet \rightarrow Br_2$;
$RCH_2\bullet + Br\bullet \rightarrow RCH_2Br$;
$RCH_2\bullet + RCH_2\bullet \rightarrow RCH_2CH_2R$; ***[4 max]***
*Award **[1]** for any termination step.*
Accept radical with or without • throughout.
Do not penalise the use of an incorrect alkane in the mechanism.

(f) (i) $CH_3OCH_2CH_3$;
$CH_3CHOHCH_3$; ***[2]***
Allow more detailed structural formulas.

(ii) $CH_3CHOHCH_3$ has higher boiling point due to hydrogen bonding;
$CH_3OCH_2CH_3$ has lower boiling point due to Van der Waals'/London/dispersion/dipole-dipole forces;
hydrogen bonds in $CH_3CHOHCH_3$ are stronger;
Allow ecf if wrong structures suggested. ***[2max]***

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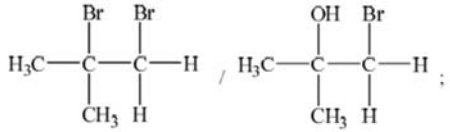
2. (a) methylpropene; ***[1]***
Accept 2-methylpropene.

(b) (i) brown/orange/yellow to colourless / bromine is decolorised; ***[1]***

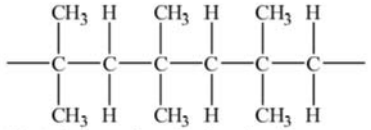
(ii) 1,2-dibromo-2-methylpropane / 1,2-dibromomethylpropane / 1-bromo-2-methylpropan-2-ol / 1-bromomethylpropan-2-ol;
Do not penalize missing commas, hyphens or added spaces.



[2]
*Award **[1]** if structure and correct name are given for 2-bromo-2-methylpropan-1-ol.*

(c) (i) synthesis of materials not naturally available/plastics;
chemically unreactive materials produced;
wide range of uses/physical properties / versatile;
cheap;
large industry;
uses a limited natural resource; ***[2 max]***
*Award **[2]** for any two.*

(ii) addition; ***[1]***

(iii)  ; [1]

Must show continuation bonds.
Ignore bracket around the 6 carbons.
Must have 6 carbons joined to each other along chain.

(iv) monomers are smaller molecules / have smaller surface area than polymers;
Accept monomers have lower molecular mass.

with weaker intermolecular/Van der Waals'/London/dispersion forces; [2]
Accept opposite argument for polymers.

Q# 18/ IB Chem/2010/s/tz1/Paper 2 Section B/Standard Level/

(b) same general formula;
same functional group;
successive members differ by CH_2;
Allow methylene for CH_2.

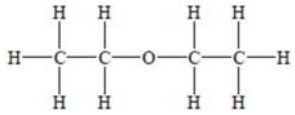
similar chemical properties;
gradually changing physical properties; [2 max]

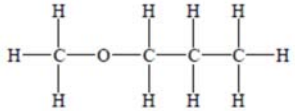
(c) (i) **A**: butan-1-ol;
B: butan-2-ol;
C: (2-)methylpropan-2-ol;
D: (2-)methylpropan-1-ol; [4]
Accept answers in the form of 1-butanol and 2-methyl-2-propanol etc.
Penalize incorrect punctuation, e.g. commas for hyphens, only once.

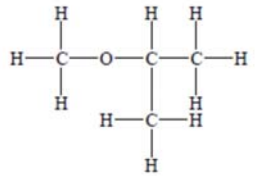
(ii) **C**/(2-)methylpropan-2-ol; [1]

(iii) **A**/butan-1-ol; [1]

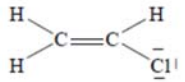
(iv) **B**/butan-2-ol; [1]

(v)  / $CH_3CH_2OCH_2CH_3$ /

 / $CH_3OCH_2CH_2CH_3$ /

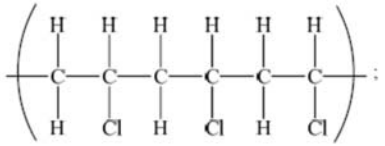
 / $CH_3OCH(CH_3)_2$; [1]

Q# 19/ IB Chem/2010/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) (i)  ;

Accept lines, dots or crosses for electron pairs.
Lone pairs required on chlorine.

(approximately)120°; [2]
Accept any bond angle in the range 113 – 120°.

(ii)  ; [1]

Brackets not required for mark.
Allow correct condensed structural formula.
Continuation bonds from each carbon are required.
Cl atoms can be above or below carbon spine or alternating above and below.

(iii) plastics are cheap/versatile/a large industry / plastics have many uses / *OWTTE*;
plastics are not biodegradeable / plastics take up large amounts of space in landfill / pollution caused by burning of plastics / *OWTTE*; [2]
Do not accept plastics cause litter.
Allow plastics don't decompose quickly / OWTTE.

(b) (i) *Step 1:*
$CH_2CHCl + H_2 \rightarrow CH_3CH_2Cl$;

Step 2:
$CH_3CH_2Cl + OH^- \rightarrow CH_3CH_2OH + Cl^-$; [2]
Allow NaOH or NaCl etc. instead of OH^- and Cl^-.
Allow abbreviated formulas C_2H_3Cl, C_2H_5Cl, C_2H_5OH.

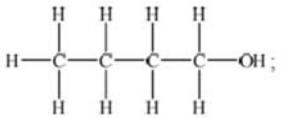
(ii) H_2SO_4/H^+/acidified **and** $Cr_2O_7^{2-}$/(potassium/sodium) dichromate;
Accept suitable oxidizing agents (e.g. $KMnO_4$ etc.) but only with acid.
Ignore missing or incorrect oxidation states in reagents.

(heat under) reflux; [2]
Second mark can be scored even if reagent is incorrect.

Q# 20/ IB Chem/2009/w/tz0/Paper 2 Section B/Standard Level/

7. (a) (i) $C_4H_9Cl + KOH \rightarrow C_4H_9OH + KCl$; [1]

(b) (i)



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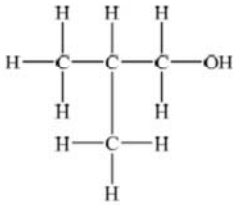

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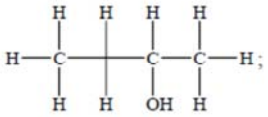

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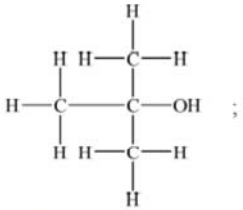


;

[4]

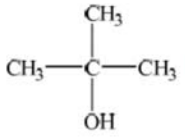
Penalise missing H atoms once only.
Accept correct condensed structural formulas.

(ii) $CH_3–CH_2–CH_2–CHO$ / $(CH_3)_2CHCHO$;
$CH_3–CH_2–CH_2–COOH$ / $(CH_3)_2CHCOOH$; *[2]*

(iii) $CH_3–CH_2–CO–CH_3$; *[1]*

(iv) orange to green; *[1]*

(v)



/ 2-methylpropan-2-ol; *[1]*

Q# 21/ IB Chem/2009/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) (i)

Isomer	A	B	C
Boiling point	36 °C	28 °C	10 °C

Award [1] if correct boiling points are assigned to 3 isomers.

increase in branching / more side chains / more spherical shape / reduced surface contact / less closely packed;
weaker intermolecular force/van der Waals'/London/dispersion forces; *[3]*
Accept the opposite arguments

(ii) *B*: 2-methylbutane/methylbutane;
C: 2,2-dimethyl propane/dimethyl propane; *[2]*
Do not penalize missing commas, hyphens or added spaces.
Do not accept 2-dimethylpropane, or 2,2-methylpropane.

(b) C_5H_{12};
Accept any two of the following explanations.

$C_5H_{11}OH$ has greater molar mass / produces less grams of CO_2 and H_2O per gram of the compound / suitable calculations to show this;
$C_5H_{11}OH$ contains an O atom which contributes nothing to the energy released / partially oxidized / *OWTTE*;
analogous compounds such as butane and butan-1-ol show a lower value for the alcohol per mole in the data book / *OWTTE*;
the total bond strength in the pentanol molecule is higher than the total bond strength in pentane;
the total amount of energy produced in bond formation of the products per mole is the same;
fewer moles of pentanol in 1 g;
pentanol requires more energy to break intermolecular forces/hydrogen bonding / *OWTTE*; *[3 max]*

(c) *Improvements [2]*
less/no particulates/C/CO/VOC's produced with CNG;
less/no SO_2/SO_x produced;

Reasons [1 max]
CO/SO_2 toxic/poisonous;
SO_2 causes acid rain;
CNG is likely to undergo complete/more combustion;
CNG has no/less sulfur impurities; *[3 max]*

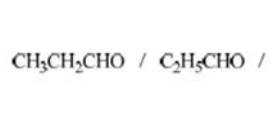
Q# 22/ IB Chem/2009/s/tz1/Paper 2 Section B/Standard Level/

7. (a) (i) butane < propanal < propan-1-ol;
butane has van der Waals/London/dispersion forces;
propanal has dipole-dipole attractive forces;
propan-1-ol has hydrogen bonding; *[4]*
imf marks are independent of the order.
Treat references to bond breaking as contradictions if the imfs are correct.

(ii) butane is least soluble;
it cannot form hydrogen bonds/attractive forces with water molecules; *[2]*

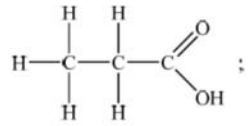
(iii) propanal and propanoic acid;

CH_3CH_2CHO / C_2H_5CHO /



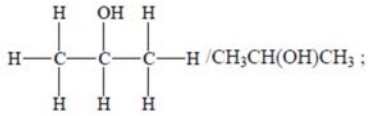
;

CH_3CH_2COOH / C_2H_5COOH /



;

[3]

(iv)  /$CH_3CH(OH)CH_3$; [1]

(v) secondary (alcohol);
propanone / acetone; [2]

(b) (i) hydrogen bromide / hydrobromic acid; [1]
Do not accept HBr, as name is asked for.

(ii) sodium hydroxide / hydroxide ions (name required);
dilute and aqueous / dilute and warm / aqueous and warm; [2]

Q# 23/ IB Chem/2009/s/TZ1/Paper 2 Section A/Standard Level/

1. (a) ester; [1]

(b) amount of oil $= \frac{1013.0}{885.6} = 1.144$ mol;

amount of methanol $= \frac{200.0}{32.05} = 6.240$ mol;

since three mol of methanol react with one mol of vegetable oil the amount of excess methanol $= 6.204 - (3 \times 1.144) = 2.808$ mol; [3]

(d) vegetable oil is mainly non-polar **and** methanol is polar / *OWTTE*;
stirring brings them into more contact with each other / increase the frequency of collisions / *OWTTE*; [2]
Do not allow simply mixing.

(e) (relative molecular mass of biodiesel, $C_{19}H_{36}O_2 = 296.55$)
maximum yield of biodiesel = 3.432 mol / 1018 g ;
percentage yield $= \frac{811.0}{1018} \times 100 = 79.67\%$; [2]
Allow 80 % for percentage yield.

(f) the carbon dioxide was absorbed by plants initially so there is no net increase / vegetable oil is not a fossil fuel / vegetable oil is formed from (atmospheric) carbon dioxide / *OWTTE*; [1]

Q# 24/ IB Chem/2008/w/tz0/Paper 2 Section B/Standard Level/

6. (a) (i) C_2H_4O ; [1]

(ii) $CH_3CH_2CH_2COOH$ / $CH_3CH_2CH_2CO_2H$;
butanoic acid; [2]

(iii) ester; [1]

(b) (i) potassium dichromate / $K_2Cr_2O_7$ / $Cr_2O_7^{2-}$ / $KMnO_4$ / MnO_4^- ;
acidified / sulfuric acid / H_2SO_4 ;
butanal;
heat under reflux / use excess oxidising agent / heat for longer / use higher temperature; [4]

(ii) $CH_3COOH + C_2H_5OH \rightarrow CH_3COOC_2H_5 + H_2O$;
Accept reversible arrow symbol and more detailed structures.

ethyl ethanoate; [2]

(iii) $HCOOCH_2CH_2CH_3$;
$CH_3CH_2COOCH_3$; [2]
Accept structures in reverse order.

(iv) A (is higher) because of (stronger) hydrogen bonding;
B (is lower as it) has (weaker) dipole-dipole attractions; [2]

Q# 25/ IB Chem/2008/s/tz1/Paper 2 Section B/Standard Level/

(c) (i) orange to green; [1]

(ii) A is propan-1-ol/1-propanol;
Do not accept propanol

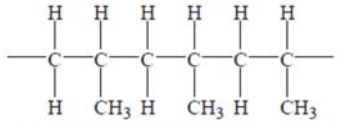
B is propanal;
C is propanoic acid; [3]

(iii) esterification / condensation;
propyl ethanoate; [2]

(iv) A has (stronger) hydrogen bonding;
B has (weaker) dipole-dipole attractions; [2]
At least one of stronger or weaker needed to score both marks.

Q# 26/ IB Chem/2008/s/TZ1/Paper 2 Section A/Standard Level/

(c) addition (polymerization);

 ; [2]

Allow CH_3 groups alternately above and below the spine.
Allow dotted/dashed lines at ends but not H-atoms.

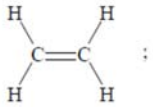
Q# 27/ IB Chem/2007/w/tz0/Paper 2 Section B/Standard Level/q5c

(iii) CH_2CHCl ;
chloroethene / vinyl chloride; [2]

Q# 28/ IB Chem/2007/w/tz0/Paper 2 Section B/Standard Level/

5. (a) (i) $C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$; [1]
State symbols not required for mark

Q# 29/ IB Chem/2007/s/tz1/Paper 2 Section B/Standard Level/

5. (a)  ;
Allow CH_2=CH_2.

a hydrocarbon that contains at least one C=C (or C≡C)/carbon-carbon double bond (or triple bond)/carbon to carbon multiple bond; [2]
Do not accept just "double bond".

(b) $C_2H_4 + H_2O \rightarrow C_2H_5OH$;
addition/hydration reaction; *[2]*

(c) heat under reflux;

EITHER

potassium dichromate(VI) / $K_2Cr_2O_7$ / $Cr_2O_7^{2-}$ and acidified / H^+;
orange to green;

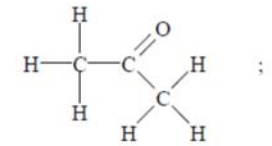
OR

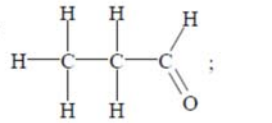
potassium permanganate / manganate(VII) / $KMnO_4$ / MnO_4^- and acidified / H^+;
purple to colourless;
Penalise wrong oxidation state, but not missing oxidation state.
ethanoic acid; *[4 max]*

(d) $CH_3COOH + C_2H_5OH \rightarrow CH_3COOCH_2CH_3 + H_2O$;
Accept $CH_3COOC_2H_5$.
sulfuric acid/ H_2SO_4 /(ortho)phosphoric acid/ H_3PO_4;
ethyl ethanoate;
solvent / flavouring / perfumes / plasticizers; *[4]*

(e) presence of double bond / multiple bond;
absence of two functional groups / no other functional groups; *[2]*

(f) (i) same molecular formula but different structural formula / arrangement of atom within a molecule / OWTTE; *[1]*

(ii) CH_3COCH_3 /  ;

CH_3CH_2CHO /  ; *[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].

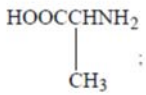
Q# 30/ IB Chem/2006/w/tz0/Paper 2 Section B/Standard Level/

5. (a) (i) $C_4H_8 + 6O_2 \rightarrow 4CO_2 + 4H_2O$; *[1]*

(ii) mix with bromine (water) / acidified $KMnO_4$/permanganate/manganate VII/ MnO_4^-;
bromine decolorized (with but–2–ene) / $KMnO_4$ decolourises; *[2]*

Q# 31/ IB Chem/2006/s/tz1/Paper 2 Section B/Standard Level/q8

(e) (i) CH_2CH_2; *[1]*

(ii)  ; *[1]*

Allow appropriate acyl chloride.

(iii) $H_2N(CH_2)_6NH_2$;
$HOOC(CH_2)_4COOH$; *[2]*
Allow correct alternative.
Accept correct names as alternatives.
If correct structure and incorrect name given, award the mark.
Penalise COOH – C once only.

(f) (addition polymers) contain C=C / C≡C;
(condensation polymers) contain two reactive/functional groups; *[2]*

(g) methyl methanoate;
$HCOOCH_3$; *[2]*
Accept other correct alternative.

Q# 32/ IB Chem/2006/s/tz1/Paper 2 Section B/Standard Level/

(c) (i) 

Allow a combination of dots, crosses or lines.
bent / V shaped / angular
104.5°;
Accept answers in range 104° to 106°.

repulsion of the two non-bonding pairs of electrons forces bond angle to be smaller / non-bonding pairs repel more than bonding pairs; *[4]*

(ii) ethanol is polar and ethane is non-polar;
ethanol forms hydrogen bonds / dipole–dipole attractions with water and ethane does not; *[2]*

(d) butane < propanone < propanol;
butane has van der Waals' forces;
Accept vdW, dispersion or London forces or attractions between temporary dipoles.
propanone has dipole-dipole attractions;
propanol has (the stronger) H-bonding; *[4]*

Q# 33/ IB Chem/2005wQ1

(d) (i) 2-methylbutanoic acid; *[1]*
Do not accept 3-methylbutanoic acid.

Q# 34/ IB Chem/2005sQ2

(c) carbon monoxide / carbon is produced;
CO is toxic / poisonous / forms carboxyhemoglobin / interferes with oxygen transport in the body;
carbon (soot) is harmful to the respiratory system; *[2 max]*
Award [1] each for any two.

Q# 35/ IB Chem/2005/w/tz0/Paper 2 Section B/Standard Level/

7. (a) same general formula/C_nH_{2n};
formulas of successive members differ by CH_2;
similar chemical properties/same functional group;
gradation/gradual change in physical properties; ***[3 max]***
*Award **[1]** each for any three.*

(b) but-2-ene;
Accept 2-butene.

strongest intermolecular/van der Waals' forces;
largest (molecular) mass/size/surface area/area of contact; ***[3]***

(c) $CH_2CHCH_2CH_2CH_3$/$CH_3CHCHCH_2CH_3$/any correct branched structure;
Accept more detailed formula.

pent-1-ene/pent-2-ene; ***[2]***
Name must match formula.
Accept 1-pentene / 2-pentene.

(d) $C_4H_8 + HBr \rightarrow CH_3CH_2CHBrCH_3$;
*Award **[1]** for all molecular formulas correct and **[1]** for correct product structure.*
*Award **[1]** for completely correct equation starting with but-1-ene.*

addition; ***[3]***

(e) oxidation / redox;
(potassium) dichromate(VI) / $Cr_2O_7^{2-}$;
(sulfuric) acid;
distilling off propanal as it is formed;
heating under reflux (to obtain propanoic acid); ***[5]***

(f) (propan-1-ol) hydrogen bonding;
(propanal) dipole-dipole attractions;
(propanoic acid) hydrogen bonding;
propanoic acid > propan-1-ol > propanal; ***[4]***

Q# 36/ IB Chem/2005/s/tz1/Paper 2 Section B/Standard Level/

8. (a) **A** CH_3CH_2COOH / $CH_3CH_2CO_2H$;
Accept C_2H_5 for CH_3CH_2.
propanoic acid;

B or **C** CH_3COOCH_3;
methyl ethanoate;

C or **B** $HCOOCH_2CH_3$;
Accept $HCOOC_2H_5$.
ethyl methanoate; ***[6]***

(b) (i) **A** forms hydrogen bonds with water;
A ionizes / dissociates to give H^+ ions; ***[2]***
Accept correct equation.

(ii) $C_2H_5COOH + NaOH \rightarrow C_2H_5COONa + H_2O$; ***[1]***
Allow ECF from A.

(iii) no C=C bond; ***[1]***
Do not accept "no double bonds".

(c) highest boiling point is **A**;
molecules of **A** can form hydrogen bonds (with other molecules of A); ***[2]***

(d) (i) esters;
flavourings / plasticizers / solvents / perfumes; ***[2]***

(ii) carboxylic acid / alkanoic acid;
alcohol / alkanol;
water; ***[3]***

(e) any feasible formula containing C=C (*e.g.* $CH_3CHC(OH)_2$ or $HOCH{=}C(OH)CH_3$);
Accept more detailed formula.
addition;
mixture is decolorised / colour change is from yellow/orange to colourless; ***[3]***
Do not accept discoloured instead of decolorised.

Q# 37/ IB Chem/2005/s/TZ1/Paper 2 Section A/Standard Level/

5.

structural formula	name
$CH_3CH_2CH_2CH_3$;	butane / n-butane;
$CH_3CH(CH_3)CH_3$;	(2)-methylpropane;

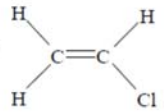
[4]

Accept more detailed formulas, penalizing missing H atoms once only.
*If more than these two formulas given, subtract **[1]** for each extra formula.*
Mark names separately. Accept these two names only.

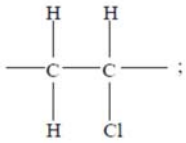
Q# 38/ IB Chem/2004wQ3

(c) molecules have insufficient energy to react (at room temperature) / wrong collision geometry / unsuccessful collisions;
extra energy needed to overcome the activation energy / E_a for the reaction; ***[2]***

Q# 39/ IB Chem/2004/w/tz0/Paper 2 Section B/Standard Level/

5. (a) (i) CH_2CHCl / $CH_2 = CHCl$ /  ; ***[1]***

(ii) addition (polymerization);
(carbon-carbon) double bond / unsaturation / *OWTTE*; ***[2]***

(iii)  ; ***[1]***

(iv) monomers have smaller molecules / surface area than polymers;
with weaker intermolecular / Van der Waals' forces; ***[2]***
Accept opposite argument for polymers.

Q# 40/ IB Chem/2004/w/TZ0/Paper 2 Section A/Standard Level/

2. (a) (i) a series of (organic) chemicals with the same general formula (C_nH_{2n+2}) / neighbouring members differing by CH_2 / similar chemical properties / gradation of physical properties / same functional group / *OWTTE* **[2 max]**
Award [1] each for any two.

(ii) a compound containing carbon and hydrogen only; **[1]**

(iii) containing only single (carbon to carbon) bonds / no multiple (carbon to carbon) bonds / *OWTTE*; **[1]**
Accept HC containing maximum number of hydrogens.

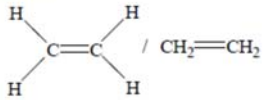
(b) (i) boiling point increases as number of carbons increases / *OWTTE*;
increased surface area / greater Van der Waals' forces / increased M_r / increased intermolecular forces / *OWTTE*; **[2]**

(ii) exothermic / energy released / products have less energy than reactants; **[1]**

(c) carbon dioxide;
water; **[2]**
Accept formulas.

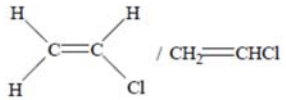
Q# 41/ IB Chem/2004/s/tz1/Paper 2 Section B/Standard Level/

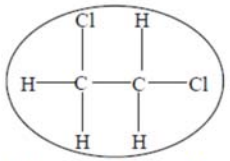
7. (a) ethene;


/ $CH_2{=}CH_2$ **[2]**

(b) **A** addition / hydration;
H_2O / water / steam;
B oxidation;
acidified $K_2Cr_2O_7$
Accept acidified $KMnO_4$. **[4]**

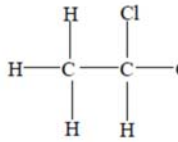
(c)


/ $CH_2{=}CHCl$


/ CH_2ClCH_2Cl ;

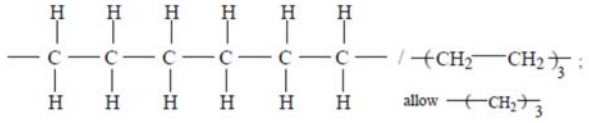
The compound formed directly may be circled or indicated by some other means. **[3]**
Accept any other structure showing a Cl atom on each C atom.

(d)


/ CH_3CHCl_2 ;

addition across a double bond occurs at both C atoms / *OWTTE*; **[2]**
If 1, 1-dichloroethane is given in (c) accept 1, 2-dichloroethane as the isomer as ECF but Award [1] max;

(e) addition polymer;


allow $-(-CH_2-)_3-$ **[2]**

Q# 42/ IB Chem/2003/w/tz0/Paper 2 Section B/Standard Level/

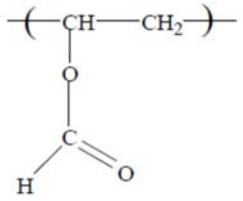
7. (a) (i) one general formula / same general formula;
differ by CH_2;
similar chemical properties;
gradual change in physical properties;
Award [1] for any two from last three

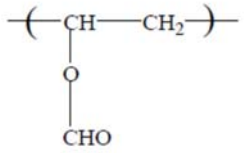
functional group: atom or group of atoms responsible for the characteristic reactions of the molecule / homologous series; **[3]**

(ii) ethanol lower / ethanoic acid higher;
due to larger mass of ethanoic acid / stronger intermolecular forces / stronger van der Waals' forces / stronger hydrogen bonding; **[2]**
No mark for H–bonding.

(c) (i) II reacts with Br_2;
II is an alkene / has unsaturated R group / $C{=}C$ present, I contains only saturated R groups; **[2]**

(ii) addition polymerization;

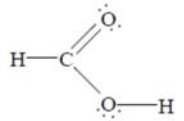




accept **[2]**

Q# 43/ IB Chem/2003/w/TZ0/Paper 2 Section A/Standard Level/

4. (a)



[1]

No mark without lone electron pairs.

Correct shape not necessary.
Do not award mark if dots / crosses and bond liens are shown.
Accept lone pairs represented as straight lines.

(b) $O-C-O = 120^\circ$ / $H-C-O = 120^\circ$;
$C-O-H \approx 109^\circ$ / $< 109^\circ$; *[2]*

No mark for 109.5°.
Accept answer in range 100-109°

(c) length: $C=O < C-O$;
strength: $C=O > C-O$;
greater number of electrons between nuclei pull atoms together and require greater energy to break; *[3]*

Or

double bonds are shorter / sing bonds are longer;
double bonds are stronger / single bonds are weaker;
Accept stonger attraction between nuclei and (bonding) electrons.

Q# 44/ IB Chem/2003/s/tz1/Paper 2 Section B/Standard Level/

8. (a) (i) butane;
$C_4H_{10}(g) + \frac{13}{2}O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$;
(ignore state symbols, accept balancing using $13O_2$)
***[1]** for all formulas and **[1]** for balancing equation.*

CO produced;
CO is poisonous / combines with hemoglobin / *OWTTE*;
or
C;
which causes respiratory problems; *[5]*

(ii) add Br_2 (water);
valid test needed to score further marks

A – no effect;
B – would decolorise Br_2 *(do not accept discolour)*; *[3]*

(iii) $CH_3CH{=}CHCH_3 + HBr \rightarrow CH_3CHBrCH_2CH_3$;
***[1]** for HBr in balanced equation, **[1]** for structure of product.*
addition; *[3]*

(b) (i) $CH_3OH + HCOOH \rightarrow HCOOCH_3 + H_2O$;
***[1]** for both reactants and **[1]** for both products (accept $C_2H_4O_2$)*
methyl methanoate; *[3]*

(ii) ethanoic acid; *[1]*

Q# 45/ IB Chem/2002/w/tz0/Paper 2 Section B/Standard Level/

6. (a) (homologous series)
group of (organic) compounds with same general formula;
neighbouring members differ by CH_2;
$C_nH_{2n+1}OH$ / any correct alkanol formula; *[3]*

(functional group)
group of atoms in a compound with characteristic chemical properties / *OWTTE*;
–OH / hydroxyl is functional group in alkanols; *[2]* *[5]*

(d) (i) bromine (water) / potassium manganate(VII) solution;
decolorises; *[2]*

(ii) $C_2H_4 + H_2O \rightarrow C_2H_5OH$; *[1]*

(iii) heat / catalyst / concentrated sulfuric acid; *[1]*

(e) (i) acidified potassium dichromate(VI);
oxidation / reduction / redox / oxidation-reduction; *[2]*

(ii) colour changes from orange to green; *[1]*
Accept any other suitable oxidising agent and correct colour change.

Q# 46/ IB Chem/2002/s/tz1/Paper 2 Section B/Standard Level/q4

(e) $HCOOCH_3$ ***[1]***;
methyl methanoate ***[1]***. *[2]*

If full structural formulas are given in (b) (ii) and (e), but the H atoms attached to the C– bonds are omitted, penalize first time only.

(f) asymmetric carbon atom / chiral centre / carbon attached to four different atoms/groups / asymmetric molecule. *[1]*

Q# 47/ IB Chem/2001/w/TZ0/Paper 2 Section A/Standard Level/

2. (a) $2C_2H_5OH + 7O_2 \rightarrow 4CO_2 + 6H_2O$

*(Award **[1]** for correct reactants and products, **[1]** for correct balancing.*
*States **not** required; do **not** accept C_2H_6O; accept with half the coefficients.)* *[2]*

(b) (i) $M_r = 88$ *[1]*
$\Delta H_c^\ominus = -3325 \pm 25$ kJ mol^{-1} *(allow for ECF)* *[1]*

(ii) The value should be (about) the same. *[1]*
Same (number and type of) bonds are being broken and made. *[1]*

*(Do **not** accept: "the compounds have the same relative molecular masses or same formulas".)*

Q# 48/ IB Chem/2001/s/tz1/Paper 2 Section B/Standard Level/

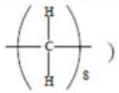
(b) Reference to H– bonding in ethanol/water *[1]*
Ethane not polar *[1]*
No H– bonds / only van der Waals *[1]*
Cholesterol mostly a non-polar chain / hydrocarbon *[1]* *[4 max]*

(c) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ *[1]*
Carbon monoxide/carbon (allow soot)/water **OR** CO/C/H_2O
(Award [1] for any two.)

(Award [1] for any one of the following:)
CO: toxic / reduces oxygen carrying capacity of red blood cells / reduces oxygen carrying capacity of haemoglobin

C (particulates): influence climate / increase atmospheric turbidity / attenuate solar radiation / cause respiratory problems *[3 max]*

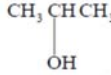
(d) Product must show **all** C (8) saturated with H and **no** double bonds *[1]*

(Allow C_8H_{18} *or* )

Addition/reduction/hydrogenation/hardening *[1]* *[2 max]*

Q# 49/ IB Chem/2000/w/TZ0/Paper 2 Section A/Standard Level/

4. (a) $CH_3CH_2CH_2OH$ 1-propanol **OR** propan-1-ol *(need both for mark)* *[1]*

 2-propanol **OR** propan-2-ol *(need both for mark)* *[1]*

(If only both names are correct or only both formulas, award [1])

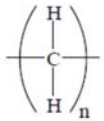
Q# 50/ IB Chem/2000/s/tz1/Paper 2 Section B/Standard Level/

6. (a) Butane has a higher boiling point than ethane since the molecule is **larger/heavier/greater M_r** *[1]*
and so has **greater intermolecular**/Van der Waals' forces. *[1]*
Ethane is non-polar whereas bromoethane is polar *[1]*
and **larger/heavier/greater M_r** *[1]*
so has greater intermolecular forces/Van der Waals' forces *[1]*
which **require more energy to break**. *[1]*
Ethanol is **more polar** than bromoethane *[1]*
and has **hydrogen bonding** which requires more energy to break. *[1]*

Note: "Intermolecular forces," "Van der Waals' forces," "more energy needed" should be credited **once** only for **any** of the 3 pairs.

(N.B. Maximum of 8 marking points taken from the 3 pairs.)

(b)

	Type of reaction	Reagent	Conditions	Structural formula
(i)	addition *[1]*	—	high pressure initiator *[2×1]*	 *[1]*

Q# 51/ IB Chem/1999/w/tz0/Paper 2 Section B/Standard Level/

4. (a) (i) From orange to green.

both colours must be stated *[1]*

(ii) In ethanol and ethanoic acid a H atom is bonded directly to an O atom so that hydrogen bonding can occur between the molecules. *[1]*
Ethanal is polar due to the more electronegative O bonded to C *[1]*
but there is no hydrogen bonding and dipole:dipole attractions are weaker than hydrogen bonds. *[1]*

Q# 52/ IB Chem/1999/s/TZ1/Paper 2 Section A/Standard Level/

3. (a) Increase in boiling point (with increasing number of carbons). *[1 mark]*

relative molecular mass increases or molecular size gets bigger; *[1 mark]*
Intermolecular forces/temporary dipole increases/more energy needed to separate molecules/overcome forces. *[1 mark]*

(b) methanol is polar (or polarity implied) *[1 mark]*
hydrogen bonding occurs (between molecules) *[1 mark]*