GCE A LEVEL MARKING SCHEME

AUTUMN 2020

A LEVEL
CHEMISTRY – COMPONENT 2
A410U20-1

INTRODUCTION

This marking scheme was used by WJEC for the 2020 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

GCE A LEVEL CHEMISTRY COMPONENT 2

ORGANIC CHEMISTRY AND ANALYSIS

AUTUMN 2020 MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark, apart from extended response questions where a level of response mark scheme is applied.

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Extended response questions

A level of response mark scheme is applied. The complete response should be read in order to establish the most appropriate band. Award the higher mark if there is a good match with content and communication criteria. Award the lower mark if either content or communication barely meets the criteria.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao	=	correct answer only
ecf	=	error carried forward
bod	=	benefit of doubt

Credit should be awarded for correct and relevant alternative responses which are not recorded in the mark scheme.

Section A

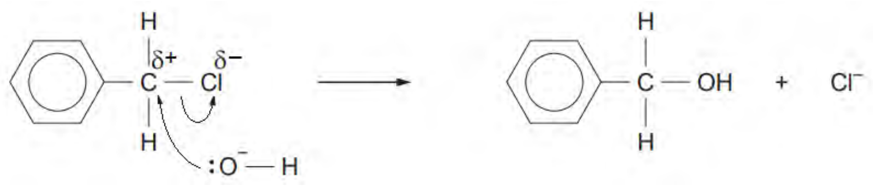
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td>accept any suitable four carbon atom containing aldehyde

e.g. $CH_3CH{=}CHCHO$ / $CH_3CH_2CH_2CHO$

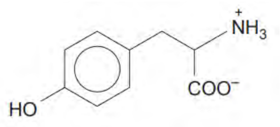
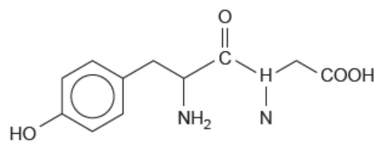
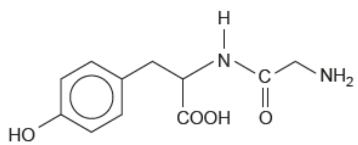
accept alicyclic compounds</td><td></td><td>1</td><td></td><td>1</td><td></td><td>1</td></tr>
<tr><td>2</td><td>(a)</td><td></td><td></td><td>$C_5H_{12}O_5$</td><td></td><td></td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>three signals (1)

two outer carbons are equivalent, central carbon is independent, remaining two carbon atoms are equivalent (1)</td><td></td><td></td><td>2</td><td>2</td><td></td><td></td></tr>
<tr><td>3</td><td>(a)</td><td></td><td></td><td>C</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td></td><td></td><td>
<table>
<tr><th rowspan="2">Compound</th><th colspan="3">Reagent added</th></tr>
<tr><th>$NaHCO_3$</th><th>$Cr_2O_7^{2-}$ / H^+</th><th>2,4-DNP</th></tr>
<tr><td>A</td><td>no reaction</td><td>green solution</td><td>no reaction</td></tr>
<tr><td>B</td><td>effervescence</td><td>green solution</td><td>no reaction</td></tr>
<tr><td>C</td><td>no reaction</td><td>green solution</td><td>orange/red ppt</td></tr>
</table>

award (1) for each correct column</td><td></td><td>3</td><td></td><td>3</td><td></td><td>3</td></tr>
</table>

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*			C_2H_2O	1			1		
	(b)	(i)		62		1		1		1
		(ii)		of the remaining nitrogen and helium the ratio by volume is 7:2 (1) volume of nitrogen = $\frac{7 \times 62}{9}$ = 48 volume of helium = $\frac{2 \times 62}{9}$ = 14 (1)		2		2		
5	*(a)*			 curly arrows (1) partial and full charges (1)	2			2		
	(b)			award (1) for any of following ethanoic acid / CH_3COOH ethanoic anhydride / $(CH_3CO)_2O$ ethanoyl chloride / CH_3COCl	1			1		1
				Section A total	**5**	**7**	**3**	**15**	**0**	**6**

Section B

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
6	*(a)*	(i)			1			1		
		(ii)		the (zwitterion) structure of tyrosine leads to ionic bonding (1) strong forces between ions, therefore more energy needed to separate the ions, leading to a high melting temperature (1)	2			2		
		(iii)		award (1) for either of following  	1			1		
		(iv)		purple coloration	1			1		1

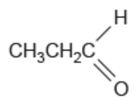
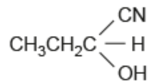
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td></td><td>(v)</td><td></td><td>M_r of tyrosine is 181

since CO_2 is lost M_r of tyramine is 44 less → 137 (1)

atom economy = $\frac{137 \times 100}{181}$ = 75.7 (1)

must be given to 3 sig figs</td><td></td><td>2</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td></td><td>triplet at ~1.1, characteristic of a —CH_3 group, must be next to a carbon atom with 2 protons (1)

quartet at ~2.8, characteristic of a —CH_2— group adjacent to a —CH_3 group (1)

ratio suggests an ethyl group, therefore the R group is CH_3CH_2 (1)</td><td></td><td>3</td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td><table><tr><th>Compound</th><th>Structure</th></tr><tr><td>T</td><td></td></tr><tr><td>U</td><td></td></tr><tr><td>V</td><td>$CH_3CH_2CH(OH)COOH$</td></tr></table>
award (1) for each correct formula</td><td></td><td></td><td>3</td><td>3</td><td></td><td>3</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 6 total</td><td>5</td><td>5</td><td>3</td><td>13</td><td>2</td><td>4</td></tr>
</table>

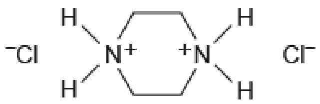
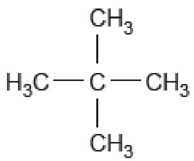
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
7	(a)			mass of butane = 10.48 – 3.52 = 6.96 moles of propane = $\frac{3.52}{44}$ = 0.0800 moles of butane = $\frac{6.96}{58}$ = 0.120 (1) 1 mol of propane gives 3 mol of CO_2 therefore 0.0800 mol propane gives 0.240 mol CO_2 (1) volume of this CO_2 = 0.240 × 24.5 = 5.88 (1) 1 mol of butane gives 4 mol of CO_2 therefore 0.120 mol butane gives 0.480 mol CO_2 volume of this CO_2 = 11.76 (1) total volume of CO_2 = 17.64 (1)		5		5	2	
	(b)			62 mg ethanethiol contain 32 mg sulfur 17 mg ethanethiol contains $\frac{32 \times 17}{62}$ = 8.8 mg of sulfur (1) therefore percentage of sulfur in the LPG = $\frac{8.8 \times 100}{600 \times 1000}$ (1) 1.5×10^{-3} / 0.0015 (1)		3		3	1	

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td></td><td>(c)</td><td></td><td></td><td>methylpropane is a branched molecule and has weaker packing / less surface area in contact (1)

as a result van der Waals forces / forces between molecules are weaker therefore less energy is needed to separate the molecules and boiling temperature is lower (1)</td><td>1</td><td>1</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(d)</td><td></td><td></td><td>award (1) for each advantage

<table>
<tr><th>Property</th><th>Advantage</th></tr>
<tr><td>Reacts with both carbon dioxide and hydrogen sulfide</td><td>other amines may not remove both gases / removes poisonous gases</td></tr>
<tr><td>It has a high boiling temperature</td><td>loss of the amine is minimised</td></tr>
<tr><td>It is immiscible with hydrocarbons</td><td>easier separation</td></tr>
<tr><td>Its reaction with both carbon dioxide and hydrogen sulfide is exothermic</td><td>lower operating costs / less equipment degradation / heat produced used elsewhere</td></tr>
</table>

credit other sensible responses - discuss at conference</td><td></td><td></td><td>4</td><td>4</td><td></td><td>2</td></tr>
<tr><td></td><td>(e)</td><td>(i)</td><td></td><td>nitrogen atoms are proton acceptors / electron pair donors</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
</table>

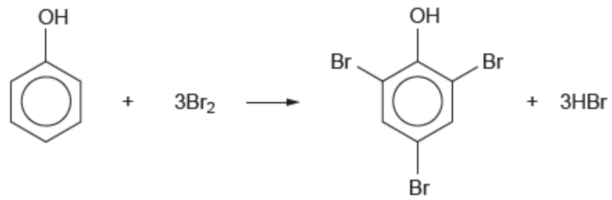
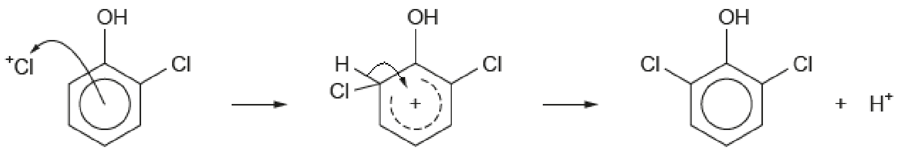
Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
		(ii)		 accept the cation without anions		1		1		
	(f)			 (1) all the hydrogen atoms are equivalent (therefore only one monochlorinated product) (1)			2	2		
				Question 7 total	**2**	**10**	**6**	**18**	**3**	**2**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*			**Indicative content** 2-methylundecanal (is an aldehyde) and will give a silver mirror with Tollens' reagent / red solid with Fehling's reagent / be oxidised by acidified dichromate, reducing this from orange to green whereas compounds **D** and **G** will not react in this way compound **D** will give a yellow precipitate with alkaline iodine, whereas 2-methylundecanal will not react in this way 2-methylundecanal contains a chiral centre and will rotate the plane of plane polarised light, compound **E** does not contain a chiral centre and will not rotate the plane of plane polarised light compound **F** only contains 11 carbon atoms / has the molecular formula $C_{11}H_{22}O$ and cannot therefore be 2-methylundecanal compound **F** only contains 11 carbon atoms and will have a lower boiling temperature than 2-methylundecanal compound **G** contains a chiral centre, as does 2-methylundecanal but will not react with Tollens' reagent to give a silver mirror / give a red solid with Fehling's reagent / be oxidised by acidified dichromate, reducing this from orange to green all the compounds will give an orange-red precipitate with 2,4-DNP, although it is likely that each precipitate will have a different melting temperature		3	3	6		4

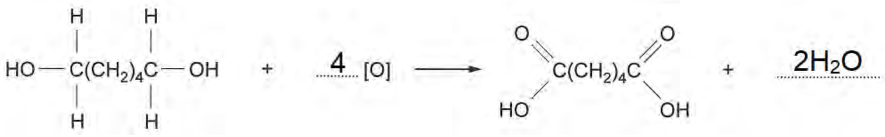
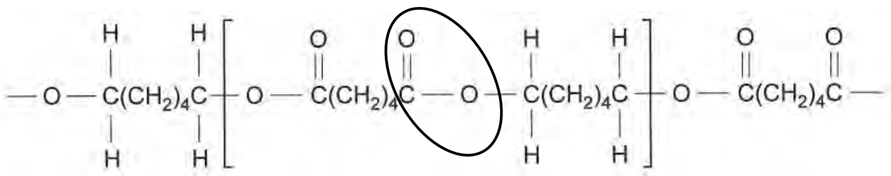
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks Appropriate tests suggested; correct observations given for 2-methylundecanal and three/four of compounds **D** to **G** in turn *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.* **3-4 marks** Some appropriate tests suggested; correct observations for 2-methylundecanal and/or some of compounds **D** to **G** *The candidate constructs a coherent account including many of the key elements of the indicative content. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks** One appropriate test suggested; correct observation for 2-methylundecanal and/or one of compounds **D** to **G** *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give an answer worthy of credit.*						

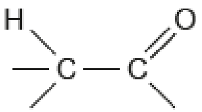
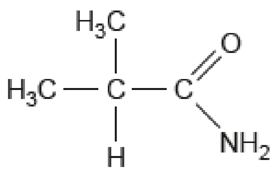
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)	(i)		$n(H_2) = \frac{4.78}{24.5} = 0.195$ (1) each mol of lycopene needs 13 mol of hydrogen n(lycopene) = $\frac{0.195}{13}$ = 0.0150 (1) M_r(lycopene) = 536.6 (1) m(lycopene) = 0.0150 × 536.6 = 8.05 (1) ecf possible throughout		4		4	2	
		(ii)		all colours other than red are absorbed accept blue / blue-green / green	1			1		
		(iii)		from graph absorption 1.24 corresponds to 0.050 g dm^{-3} (1) mass in 10 cm^3 of hexane is 0.00050 / 5.0 × 10^{-4} g (1) percentage = $\frac{5.0 \times 10^{-4} \times 100}{20}$ = 0.0025 (1)	1	2		3	1	
		(iv)		lycopene is a hydrocarbon and does not contain any polar groups that can hydrogen bond with water accept correct references to intermolecular bonding		1		1		

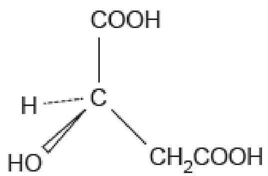
Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(c)			as the number of conjugated carbon to carbon double bonds **<u>increases</u>**, the wavelength of their absorption maxima **<u>increases</u>**, the frequency **<u>decreases</u>** and the energy **<u>decreases</u>** award (2) for **all** four correct award (1) for any **three** correct			2	2		
	(d)			the peak given by lycopene is (very much) larger than the others (as it is the main coloured component) (1) run a chromatogram with pure lycopene and compare the retention times (1)		1	1	2		
				Question 8 total	**2**	**11**	**6**	**19**	**3**	**4**

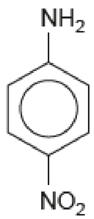
Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(a)*	(i)				1		1		
		(ii)		bromine decolourised (1) white precipitate (1)	2			2		2
	(b)			 curly arrows (1) Wheland intermediate (1) H^+ (1)		3		3		
	(c)	(i)		O—H bond is weakened by oxygen lone pair interaction with the ring / the anion is more stable (due to stabilisation of the oxygen lone pair with the ring) (1) ethanol cannot react in this way and is therefore not acidic (1)		2		2		

Question				Marking details	AO1	AO2	AO3	Total	Maths	Prac
		(ii)		award (1) for any of following • reaction would involve nucleophilic attack on the phenol by an OH^- • the ring is electron rich and not susceptible to attack by nucleophiles • aromatic C—Cl bond is stronger than aliphatic C—Cl bond		1		1		
	(d)			some 2,6-dichlorophenol remains unreacted and this is compensated for by polychlorination (1) other dichlorinated isomers are formed (1)			2	2		
	(e)	(i)		the major product is 2,4-dichlorohexane because the reaction proceeds via the secondary carbocation (1) this is more stable / more easily formed than the primary carbocation (needed to form 1,6-dichlorohexane) (1)			2	2		
		(ii)		(aqueous) sodium hydroxide	1			1		1

Question				Marking details	AO1	AO2	AO3	Total	Maths	Prac
					AO1	AO2	AO3	Total	Maths	Prac
		(iii)		 H_2O produced (1) balancing (1)	2			2		
		(iv)	I	small molecule / water is eliminated	1			1		
			II	 accept any ester linkage	1			1		
		(v)		ammonia / NH_3	1			1		1

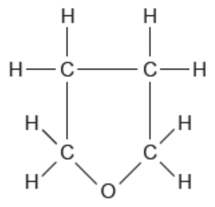
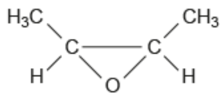
Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(f)			award (1) for identification of signals at 1.2 and 2.4 at 1.2 R—CH_3 at 2.4  from peak areas R group must contain 6 equivalent protons and 1 'single' (1)  (1)			3	3		
				Question 9 total	**8**	**7**	**7**	**22**	**0**	**4**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
10	*(a)*	(i)		n(NaOH) = $\frac{0.120 \times 5.60}{1000}$ = 6.72×10^{-4} (1) n(malic acid) = $\frac{6.72 \times 10^{-4}}{2}$ = 3.36×10^{-4} mass malic acid = $3.36 \times 10^{-4} \times 134 = 0.0450$ (1) percentage malic acid = $\frac{0.0450 \times 100}{6.80}$ = 0.66 (1)		3		3	2	
		(ii)		amount of water is immaterial as it does not take part in the reaction / only the apple juice contains malic acid / same number of moles of malic acid present		1		1		1
		(iii)		award (1) each for any two of following • use a larger sample of apple juice – this will give a larger titre • use NaOH(aq) of lower concentration – this will give a larger titre • repeat several times			2	2		2
	(b)	(i)			1			1		

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
		(ii)		c = $\frac{100 \times \alpha}{[\alpha^{20}D] \times L}$ = $\frac{100 \times 4.5}{27 \times 1}$ = 16.6 (1) c = 166 g dm^{-3} (1) c = 1.24 mol dm^{-3} (1)		3		3	2	
	(c)	(i)		isomerism caused by atoms taking up different positions in space	1			1		
		(ii)		malic acid shows optical isomerism as it has a chiral centre / asymmetric carbon atom (1) maleic acid and fumaric acid do not have a chiral centre and differ only by the positions of the groups around the C=C double bond / references to *E-Z* isomerism (1)		2		2		
	(d)	(i)		Sn and conc. HCl	1			1		1
		(ii)		ethanoyl chloride / ethanoic anhydride / CH_3COCl / $(CH_3CO)_2O$	1			1		1
		(iii)		 and $CH_3COO^-Na^+$ (charges unnecessary)		1		1		

Question				Marking details	Marks available					
					AO1	**AO2**	**AO3**	**Total**	**Maths**	**Prac**
	(e)	(i)		stage 1 room temperature / ~20°C / temperatures > 10°C (1) stage 2 5-10°C (1)	2			2		2
		(ii)		NaCl + H_2O		1		1		
				Question 10 total	**6**	**11**	**2**	**19**	**4**	**7**

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
11	*(a)*	(i)		67.5% yield of the ester ⇨ 0.0236 mol (1) M_r = 198 mass = 198 × 0.0236 = 4.68 (1)		2		2		
		(ii)		0.0236 mol CO_2 formed along with 0.0236 mol phenyl benzoate (1) 0.0350 – 0.0236 = 0.0114 mol decomposed to form diphenyl 2 × 0.0114 mol CO_2 also formed (1) total mol CO_2 = 0.0236 + 0.0228 = 0.0464 mol (1) volume CO_2 = 0.0464 × 24.5 = 1.137 (1)		2	2	4	2	
		(iii)	I	hydrolysis	1			1		
			II	filter, wash (and dry) accept 'filtration'	1			1		1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(b)			**Indicative points** $pV = nRT$ $n = \frac{7.80 \times 10^{4} \times 936 \times 10^{-6}}{8.31 \times 353} = 0.0249$ $M_r = \frac{1.80}{0.0249} = 72$ 66.6 % carbon mass ⇨ 0.666 × 72 = 48 therefore four carbon atoms per molecule must contain only one oxygen atom per molecule (as with two M_r would exceed 72) must be eight H atoms to make M_r 72 ⇨ molecular formula C_4H_8O from infrared information ⇨ no C=C, C=O or O—H bonds so must be C—O bond signals at 25.8 and 68.0 ppm identified possibilities are  		3	3	6	2	

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
				5-6 marks Appropriate conclusions drawn from each piece of information; correct structure given *The candidate constructs a relevant, coherent and logically structured account including all key elements of the indicative content. A sustained and substantiated line of reasoning is evident and scientific conventions and vocabulary are used accurately throughout.* **3-4 marks** Conclusions drawn from most pieces of information; sensible attempt at a structure based on those conclusions *The candidate constructs a coherent account including many of the key elements of the indicative content. Some reasoning is evident in the linking of key points and use of scientific conventions and vocabulary is generally sound.* **1-2 marks** Simple conclusions drawn from some of the information *The candidate attempts to link at least two relevant points from the indicative material. Coherence is limited by omission and/or inclusion of irrelevant materials. There is some evidence of appropriate use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give an answer worthy of credit.*						
				Question 11 total	**2**	**7**	**5**	**14**	**4**	**1**

COMPONENT 2: ORGANIC CHEMISTRY AND ANALYSIS

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Question	AO1	AO2	AO3	Total	Maths	Prac
Section A	5	7	3	15	0	6
6	5	5	3	13	2	4
7	2	10	6	18	3	2
8	2	11	6	19	3	4
9	8	7	7	22	0	4
10	6	11	2	19	4	7
11	2	7	5	14	4	1
Totals	30	58	32	120	16	28