

GCE

Chemistry B (Salters)

Unit **F332**: Chemistry of Natural Resources

Advanced Subsidiary GCE

Mark Scheme for June 2016

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
	Benefit of doubt given
	Contradiction
	Incorrect response
	Error carried forward
	Transcription error
	Benefit of doubt not given
	Power of 10 error
	Omission mark
	Error in number of significant figures
	Correct response
	Wrong physics or equation

Abbreviations, annotations and conventions

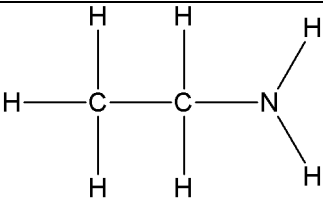
Annotation	Meaning
/	alternative and acceptable answers for the same marking point
(1)	Separates marking points
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Question			Answer	Mark	Guidance
1	a	i	<u>Any TWO from:</u> ✓✓ Consist entirely of carbon atoms Giant (network) / giant (lattice) Covalent	2	Must have the idea that it consists of only carbon ALLOW giant structure. IGNORE Macromolecular DO NOT ALLOW 'covalent' mark if there are references to ionic or intermolecular bonds or molecules in either substance.
1	a	ii	<u>Two from:</u> Every C bonded to 4 C ✓ Diamond doesn't have layers ✓ 3-dimensional/3D OR tetrahedral OR bond angle 109.5° ✓ Does not have delocalised electrons. ✓	2	Answer must imply 'each', 'every' or 'all' carbons to score the mark. IGNORE Free electron(s)
1	b		$44/12 \times 51 (= 187)$ ✓ OR $51/720 \times 60 \times 44 (= 187)$ ✓ sf mark: 190g ✓	2	ALLOW sf mark for any 2 sig fig answer that follows from any calculation 3.1 scores 1 (sf mark for incomplete calculation)
1	c	i	High pressure (under the ocean keeps the CO_2 in place) ✓ AW OR it will dissolve in seawater (before it can escape) AW ✓	1	ALLOW becomes aqueous

Question			Answer	Mark	Guidance
1	c	ii	<i>Two from:</i> Plant more trees/plants/afforestation/reforestation (AW) ✓ Promote photosynthesis by phytoplankton (AW) ✓ Reacting the CO₂ with lime / slaked lime / other suitable named solid / metal oxides ✓ Disposing of it in an old mine / well / pump it into rocks/ other suitable disposal site ✓	2	NOT methods of putting less CO₂ into the atmosphere, like burning less fossil fuel. IGNORE Lime water IGNORE “carbon capture methods” unless specified
1	c	iii	Carbon monoxide causes (photochemical) smog OR is poisonous/toxic AW ✓ Carbon dioxide causes global warming/ greenhouse effect ✓	2	ALLOW warming of atmosphere/ increases global temperature IGNORE greenhouse gas
1	d		(Increased acidity) moves equilibrium (position) in equation 1.2 to the left / to the reactants / named reactant ✓ Increased CO₂(aq) moves equilibrium (position) of equation 1.1 to the left / to the reactant / towards CO₂ (g) ✓ CO₂ (g) (concentration) increases ✓	3	For MP1 and MP2 ALLOW 1 mark if describe what is happening in equations 1.2 and 1.1 (in correct sequence) but do not mention equilibrium. ALLOW 2 marks if equilibrium is stated in 1.2 or 1.1 and has described what is happening in both equations. Equation numbers can be implied Maximum of 1 mark for an incorrect sequence (ie 1.1 then 1.2) IGNORE Produces more CO₂
1	e	i	<u>Bonds</u> (in CO₂) absorb ir / <u>bonds</u> in CO₂ vibrate (more) / increases vibrational energy of <u>bonds</u> in CO₂ ✓ Only certain frequencies/wavelengths/wavenumbers of ir are absorbed / bonds vibrate at specific frequencies ✓	2	IGNORE references to emitting Must mention absorb somewhere in answer for mp2

Question			Answer	Mark	Guidance
1	e	ii	Energy = 21.7×1000 (= 21700) J ✓ Energy in J / 6.02×10^{23} (= 3.60×10^{-20}) J ✓ Frequency = energy / 6.63×10^{-34} and evaluate (= 5.44×10^{13} Hz) ✓	3	First mark is for converting 21.7 from kJ to J i.e.: multiply by 1000. Second mark is for dividing by 6.02×10^{23} (the Avogadro constant). ALLOW ecf To get second and third marks, there must be a correct evaluation ALLOW ecf IGNORE sig figs. ALLOW 5.43×10^{13} Hz unless there is an obvious rounding error 3.27×10^{37} scores 2 (not divided by Avogadro constant) A completely correct answer on its own scores 3 marks.
				19	

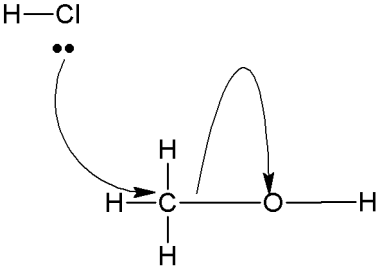
Question			Answer	Mark	Guidance
2	a		Tetrafluoroethene has stronger/more instantaneous (dipole) – induced dipole forces/bonds (than ethene) <i>ORA</i> ✓ As it has more electrons /is a bigger molecule (than ethene) <i>ORA</i> ✓ More energy needed to separate molecules (than ethene) <i>ORA</i> OR more energy needed to break/overcome imb (than in ethene) <i>ORA</i> ✓	3	IGNORE id-id in mp1 but ALLOW for mp3 ALLOW van der Waals, London forces ALLOW fluorine has more electrons mp1, mp2 and mp3 must be comparisons ALLOW mp3 if incorrect imf's are stated
2	b		Either: <pre> H H F F F F .---C---C---C---C---C---C---. H H F F F F </pre> OR <pre> F F H H F F .---C---C---C---C---C---C---. F F H H F F </pre> ✓	1	Can have first diagram reversed (i.e.: with the 2 CH₂s at the right). Must show end bonds Can use other representations, such as skeletal. IGNORE brackets
2	c		Copolymer ✓	1	DO NOT ALLOW co-polymerisation ALLOW AB polymer
2	d		ETFE does not form hydrogen bonds with water. ✓	1	ALLOW: Intermolecular bonds between ETFE and water are weaker than the water-water interactions OR dissolving would need more imbs to be broken than would be made.
2	e	i	Carbocation ✓	1	ALLOW carbonium ion DO NOT ALLOW carboncation

Question			Answer	Mark	Guidance
2	e	ii	(Partially) positively charged species / electron deficient reagent / electron pair acceptor <i>AW</i> ✓ <u>bonds</u> by accepting a <u>pair</u> of electrons/ ✓	2	ALLOW atom/molecule/positive ion
2	e	iii	Bromide (ion) / Br^- attacks / bonds with carbocation OR Bromide (ion) / Br^- attacks / bonds with intermediate A ✓ Chloride (ion) / Cl^- attacks / bonds with carbocation OR Chloride (ion) / Cl^- attacks / bonds with intermediate A ✓ Attack by Bromide (ion) / Br^- gives $\text{CH}_2\text{BrCH}_2\text{Br}$ OR Attack by Chloride (ion) / Cl^- gives $\text{CH}_2\text{ClCH}_2\text{Br}$ ✓	3	ALLOW 'attract' for 'attack' provided it leads to a reaction/product. ALLOW forms a bond with ALLOW reacts with ALLOW C^+ or cation for carbocation ALLOW 1 mark for: Carbocation / intermediate A is attacked by nucleophiles OR species carrying negative charge Referring to Chlorine /Bromine (ions) loses mp1/mp2 but not mp3 Referring to Br^- or Cl^- as electrophiles/electron pair acceptors negates one mark ALLOW marks from suitable diagrams.
2	f	i	Water ✓ Hydroxide (ions) ✓	2	ALLOW formulae (H_2O or OH^-) Allow Hydroxyl <u>ion</u>
2	f	ii	 ✓	1	Must show all atoms and all bonds. IGNORE bond angles and lone pairs
2	f	iii	Amine(s). ✓	1	IGNORE alkyl, primary DO NOT ALLOW ammine ALLOW amino alkane

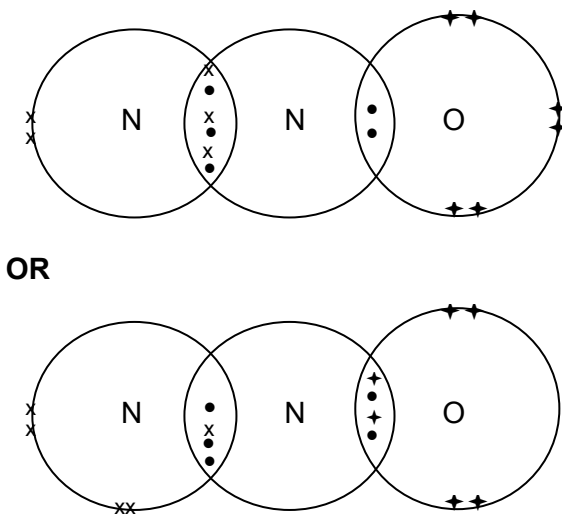
Question			Answer	Mark	Guidance															
2	f	iv	(At higher temperatures): particles have more <u>kinetic energy</u> OR particles move faster OR more collisions per unit of time OR more frequent collisions ✓ more <u>collisions</u> are successful / effective OR more <u>collisions</u> have (total) energy of at least the activation energy / more particles <u>collide</u> with an energy $\geq E_a$ ✓	2	ALLOW molecules or ions for particles ALLOW reverse argument throughout. IGNORE KE Must be clear that collisions are between particles/molecules/ions, not reactants or similar wording. DO NOT ALLOW more chance of / likelihood of collisions. IGNORE more particles have energy $\geq$ than E_a															
2	g	i	<table><thead><tr><th>Absorption ranges / cm^{-1}</th><th>Bond</th><th></th></tr></thead><tbody><tr><td>3200 - 3640</td><td>O-H</td><td>✓</td></tr><tr><td>Plus one of:</td><td></td><td></td></tr><tr><td>1050 - 1300</td><td>C-O</td><td></td></tr><tr><td>2850 – 2950</td><td>C-H</td><td>✓</td></tr></tbody></table>	Absorption ranges / cm^{-1}	Bond		3200 - 3640	O-H	✓	Plus one of:			1050 - 1300	C-O		2850 – 2950	C-H	✓	2	ALLOW OH range $3200\text{-}3600\text{ cm}^{-1}$ or $3600 - 3640\text{ cm}^{-1}$ Mark is for a correct range within those given and correct bond in each case. ALLOW OH, CH, CO but bond must only be between atoms DO NOT ALLOW lower case letters
Absorption ranges / cm^{-1}	Bond																			
3200 - 3640	O-H	✓																		
Plus one of:																				
1050 - 1300	C-O																			
2850 – 2950	C-H	✓																		
2	g	ii	Fingerprint (region) ✓ Unique/distinct/characteristic (part of the IR spectrum) to the compound <i>AW</i> OR can be used to identify the compound (by comparison with a database) OR Can differentiate between similar molecules OR Unique for every molecule ✓	2	ALLOW ‘molecule’, ‘substance’, ‘chemical’ for compound DO NOT ALLOW ‘element’															

Question			Answer	Mark	Guidance												
2	h		<table><tr><th>Oxidation conditions</th><th>Formula of functional group of product</th><th>Homologous series of product</th><td></td></tr><tr><td>Heat and immediately distil</td><td>(-)CHO</td><td>Aldehyde</td><td>✓</td></tr><tr><td>Heat under reflux</td><td>(-)CO₂H</td><td>Carboxylic acid</td><td>✓</td></tr></table>	Oxidation conditions	Formula of functional group of product	Homologous series of product		Heat and immediately distil	(-)CHO	Aldehyde	✓	Heat under reflux	(-)CO ₂ H	Carboxylic acid	✓	2	Mark is for correct name of product and correct homologous series in each case. ALLOW CH₃CHO and CH₃CO₂H/ CH₃COOH/ COOH or 'R' group DO NOT ALLOW COH ALLOW Full structural formulae
Oxidation conditions	Formula of functional group of product	Homologous series of product															
Heat and immediately distil	(-)CHO	Aldehyde	✓														
Heat under reflux	(-)CO ₂ H	Carboxylic acid	✓														
				24													

Question			Answer	Mark	Guidance
3	a		$[\text{Ne}] \quad 3s \quad \boxed{\uparrow\downarrow} \quad 3p \quad \boxed{\uparrow\downarrow} \quad \boxed{\uparrow\downarrow} \quad \boxed{\uparrow\downarrow}$ ✓	1	ALLOW use of other arrow symbols (such as 1, as long as – in each box – one points up and one down).
3	b		$2 \text{ NaCl} + 2 \text{ H}_2\text{O} \rightarrow \text{Cl}_2 + \text{H}_2 + 2\text{NaOH}$ ✓	1	IGNORE state symbols All parts in bold need to be present in the response.
3	c	i	They bond to the negative groups on the resin / membrane AND block the movement of Na^+ ions through the resin / membrane. OR ions may pass through the resin / membrane AND form group II hydroxides / contaminate the NaOH ✓	1	
3	c	ii	$\text{Mg}^+ (\text{g}) \rightarrow \text{Mg}^{2+} (\text{g}) + \text{e}^-$ ✓✓ Award marks for: Equation ✓ State symbols ✓	2	Mark separately ALLOW e without a sign for the electron symbol or ${}_{-1}^0\text{e}$ ALLOW $\text{Mg}^+ (\text{g}) - \text{e}^- \rightarrow \text{Mg}^{2+} (\text{g})$ IGNORE state symbol on electron NOT capital 'G' for state symbol ALLOW 1+ charge but NOT +1 or +2
3	c	iii	Outer shell / outermost electron of Mg AND is closer to the nucleus (than Ca) / shielded less (than Ca) (ORA) OR Mg has fewer electron shells between outermost electron and the nucleus (than Ca) (ORA) ✓ <u>Nuclear</u> attraction (to electron) is stronger/greater OR attraction/pull from the <u>nucleus/nuclei</u> is stronger/greater AND more energy is needed to remove an electron AW (ORA) ✓	2	Mark separately Must be a comparison. DO NOT ALLOW 'molecule' ALLOW descriptions for outer such as 'furthest from the nucleus', 'in highest energy level', 'valence electron', $3s^1$ and $4s^1$ electrons NOT 'it' for magnesium but second mark does not need element specified. Nucleus / nuclear / nuclei must be correctly spelt once for both marks to be awarded. NOT 'harder to remove' or 'to overcome attraction'

Question			Answer	Mark	Guidance
3	d	i	 Marks are awarded as follows: mp1 Lone pair and start of curly arrow from it in correct place ✓ mp2 End of curly arrow from Cl in correct place ✓ mp3 Curly arrow from C-O bond to O ✓	3	DO NOT ALLOW single headed (half-curly) arrows. However, if candidate draws two single headed (half-curly) arrows to the correct positions then award 1 mark for mp2 and mp3 If Cl⁻ instead of HCl then maximum 2 marks IGNORE arrow from H-Cl bond to Cl Mp1 arrow must start close to lone pair Mp2 Curly arrow must be drawn carefully starting from the Cl and pointing to the C atom or an imaginary line between C and Cl Mp3 Curly arrow must be drawn carefully starting from the bond and pointing to the O atom Any additional arrow negates 1 mark Mark separately. IGNORE further reaction steps IGNORE partial charges on atoms ALLOW: marks can be awarded for SN1 mechanism which has attack by Cl⁻ to the C⁺ atom. Do not award MP3 if leaving group is OH⁻ and not H₂O
3	d	ii	Nucleophilic ✓ Substitution ✓	2	ALLOW answers indicated in other ways, such as circles, ticks Each additional underline negates a mark.
3	e	i	Burette ✓	1	ALLOW small spelling error (e.g.: 2 rs or one t). NOT biuret.
3	e	ii	$\text{Ba(OH)}_2 + 2 \text{HCl} \rightarrow \text{BaCl}_2 + 2 \text{H}_2\text{O}$	1	IGNORE state symbols

Question			Answer	Mark	Guidance
3	e	iii	Moles $\text{Ba}(\text{OH})_2 = (19.6/1000) \times 0.100 (= 1.96 \times 10^{-3}) \checkmark$ Moles $\text{H}^+ = 2 \times \text{moles Ba}(\text{OH})_2 (= 3.92 \times 10^{-3})$ OR $2\text{H}^+ + \text{Ba}(\text{OH})_2 \rightarrow 2\text{H}_2\text{O} + \text{Ba}^{2+} \checkmark$ Moles $\text{H}^+ = 2 \times \text{moles Ba}(\text{OH})_2 / 50 (= 7.84 \times 10^{-5})$ Previous ans $\times 1000 (= 7.84 \times 10^{-2}) \checkmark$	3	ALLOW 2 or more sf Ecf from incorrect mole ratio 0.0196 scores 2 (have divided by 2, not x2) 0.0392 scores 2 (have used 1:1 ratio) IGNORE sig figs. A completely correct answer on its own scores 3 marks.
				17	

Question			Answer	Mark	Guidance
4	a		Sodium sulfate / Sodium sulphate/ Na_2SO_4 or other salt with an anhydrous form ✓	1	ALLOW silica gel (but not just silica), sodium carbonate, calcium chloride, magnesium chloride, copper sulfate (this is only a selection of suitable responses) or correct formula for a salt with an anhydrous form. DO NOT ALLOW calcium carbonate, sodium hydrogen carbonate and conc sulphuric acid.
4	b	i	(Reaction of N_2 and O_2 during) lightning OR forest fires OR from bacterial processes OR photodissociation of NO_2 AW. ✓	1	
4	b	ii	Burning fuel in vehicle engines / putting fertilisers onto soil / use of aerosol spray /burning fossil fuels to generate electricity AW ✓	1	Answer must be an <u>activity</u> (e.g.: driving a vehicle) DO NOT ALLOW 'burning a fuel' without a context.
4	b	iii	Dinitrogen oxide ✓	1	ALLOW nitrogen (I) oxide or dinitrogen monoxide DO NOT ALLOW Dinitrogen (I) oxide
4	c		 OR Bonding electrons correct ✓ Lone pairs correct ✓	2	Any two or three different symbols can be used to represent the electrons of different atoms. Candidate does not need to draw circles for electron shells. It MUST be clear that pairs of electrons are being shared between the two Ns and the N and the O. IGNORE inner shell electrons. Diagrams showing NO_2 scores 0

Question			Answer	Mark	Guidance									
4	d		78% = 780000 ppm ✓ 780000/0.38 = 2.1 x 10 ⁶ times more ✓ OR 0.38ppm = 3.8 x 10 ⁻⁵ % ✓ 78/3.8x10 ⁻⁵ = 2.1 x 10 ⁶ times more ✓	2	ALLOW 2 or more sf ALLOW ecf from an incorrect conversion Correct answer scores 2									
4	e		H₃C H C=C H CH₃ E-but-2-ene H H C=C H₃C CH₃ Z-but-2-ene Marks are for: Diagrams correctly drawn ✓ But-2-ene for both ✓ E/Z correct way round✓	3	Mark independently No more than 2 bonds above or below the C=C ALLOW skeletal structures ALLOW ambiguous attachments IGNORE Cis /Trans IGNORE Brackets around E/Z and hyphens									
4	f		<table><tr><td>Component of air</td><td>Name</td><td>Formula</td></tr><tr><td>A</td><td>Oxygen</td><td>O₂</td></tr><tr><td>B</td><td>Argon</td><td>Ar</td></tr></table> ✓	Component of air	Name	Formula	A	Oxygen	O ₂	B	Argon	Ar	1	All correct for the mark.
Component of air	Name	Formula												
A	Oxygen	O ₂												
B	Argon	Ar												
4	g	i	Evidence from more than one source, or from two or more different surveys. (AW) ✓	1										

Question			Answer	Mark	Guidance
4	g	ii	Homogeneous ✓	1	DO NOT ALLOW Homolytic
4	h		1. Both have hydrogen bonding ✓ 2. Lone pair on oxygen ✓ 3. (bonds to) hydrogen with δ^+ charge on another molecule ✓ 4. Ice is less dense because: molecules get further apart (ORA) OR 'more open structure' ✓ 5. (Intermolecular bonds) keep ice in a lattice / regular arrangement / crystalline structure / tetrahedral structure / ordered (AW) ✓ <u>QWC:</u> (For same numbers of water molecules) ice takes up more room/space than liquid water, leading to lower density (of ice). (AW) ✓	5 1	MP2: NOT lone pair on oxygen molecule MP3: DO NOT ALLOW δ^+ hydrogen molecule DO NOT ALLOW negative oxygen ALLOW partially positive (AW) MP2, MP3: ALLOW lone pair on O and $H^{\delta+}$ from a diagram but must be H of OH group that has the partial positive charge, including anything between the molecules. MP4: Must be a comparison ALLOW any idea of greater separation of molecules Here, including anything between the molecules MP5: mention of 'air', 'oxygen' between molecules negates this mark, but IGNORE 'empty space' or 'open space'. IGNORE molecules less/more dense IGNORE strength of H bonds in water/ice
				20	

Question			Answer	Mark	Guidance
5	a		Photochemical smog ✓	1	
5	b	i	Any TWO from: Vehicle emissions ✓ Forests ✓ Plants ✓	2	
5	b	ii	$\text{O}_3 + \text{CH}_3\text{CH}=\text{CH}_2 \rightarrow \text{CH}_3\text{CHO} + \cdot\text{O}-\text{O}-\cdot\text{CH}_2$ OR $\text{O}_3 + \text{CH}_3\text{CH}=\text{CH}_2 \rightarrow \text{H}_2\text{CO} + \cdot\text{O}-\text{O}-\cdot\text{CHCH}_3$ Right-hand side correct ✓ Left-hand side correct ✓	2	'Dots' for radicals are required here. ALLOW CH_3CHCH_2 ALLOW $\text{O}=\text{O}-\text{O}$ or with charges, ALLOW skeletal formulae. ALLOW full structural formulae of organic molecules IGNORE intermediate steps.
5	c	i	One from: $\text{CH}_3\cdot + \text{CH}_3\cdot \rightarrow \text{C}_2\text{H}_6$ $\text{Cl}\cdot + \text{CH}_3\cdot \rightarrow \text{CH}_3\text{Cl}$ $\text{Cl}\cdot + \text{Cl}\cdot \rightarrow \text{Cl}_2$ ✓	1	ALLOW equations without the radical 'dots'.
5	c	ii	Reaction only involves bond formation / making (and no bond breaking). ✓	1	Must make it clear that it is only bond making that occurs
5	c	iii	$\text{CCl}_3\cdot + \text{Cl}_2 \rightarrow \text{Cl}\cdot + \text{CCl}_4$ ✓	1	ALLOW equations without radical 'dots'.
5	d		Two from: ✓✓ Regulates ozone levels / ozone depletion Photochemical smog <u>formation</u> Ozonolysis (of alkenes) / reaction of ozone with alkenes Reaction with SO_2 Reaction with NO_2	2	IGNORE forming (Criegee) biradicals ALLOW equations ALLOW formation of sulphuric acid / SO_3 ALLOW formation of nitric acid / NO_2 ALLOW formation of organic nitrates

Question			Answer	Mark	Guidance
5	e	i	Species with two unpaired electrons on different atoms. ✓	1	ALLOW a biradical carbonyl oxide / a carbonyl oxide with 2 unpaired electrons ALLOW molecules instead of species but not atoms
5	e	ii	C-Cl bond needs higher frequency radiation (to break than C-I bond). ✓ Higher frequency equates to higher energy AND C-Cl bond is stronger/has higher bond enthalpy than C-I bond OR Higher frequency equates to higher energy AND C-Cl bond needs more energy (to break than C-I bond). ✓	2	ORA throughout Must be comparisons throughout IGNORE references to electronegativity ALLOW $E=h\nu$ as an explanation of high frequency equating to higher energy
5	f		<u>Example:</u> either $\bullet\text{CH}_2\text{OO}\bullet$ OR $\bullet\text{CH}(\text{CH}_3)\text{OO}\bullet$ ✓ <u>How they form:</u> Volatile unsaturated compounds react with ozone. ✓ <u>Why only recently detected - TWO from:</u> ✓✓ They react extremely quickly. Only form in certain parts of the atmosphere where conditions are right. (AW) Alkene ozonolysis reactions are too slow in lab systems to generate enough Criegee biradicals to detect. <u>How they have been detected:</u> (Detected by) PIMS/Photoionisation Mass Spec(troscopy). ✓ High intensity light beams. ✓	6	ALLOW alkenes react with ozone/ alkene ozonolysis. ALLOW They react very rapidly/they are highly reactive therefore very short lived

Question			Answer	Mark	Guidance
			<u>QWC:</u> Linking very quick reactions of Criegee biradicals with the fact they have two unpaired electrons. ✓	1	Please indicate QWC mark using red cross or green tick on the right of the pencil icon on the answer screen.
				20	

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