OCR
Oxford Cambridge and RSA

GCE

Chemistry B (Salters)

Unit **F332:** Chemistry of Natural Resources

Advanced Subsidiary GCE

Mark Scheme for June 2015

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

These are the annotations, (including abbreviations), including those used in scoris, which are used when marking

Annotation	Meaning
BP	Blank Page – this annotation **must** be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
BOD	Benefit of doubt
CON	Contradiction
	Cross
ECF	Error carried forward
I	Ignore
NAQ	Not answered question
NBOD	Benefit of doubt not given
NGE	Not good enough
RE	Rounding error
REP	Repeat
SEEN	Noted but no credit given
SF	Error in no. of significant figures
	Tick
^	Omission mark

Subject-specific Marking Instructions

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	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

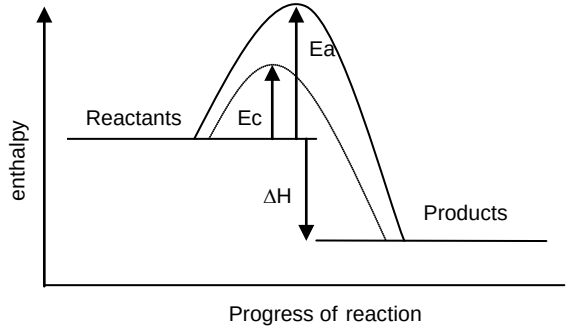
All questions must be annotated with a tick where the mark is given (please refer to Scoris Annotations document from your Team Leader).

Additional objects: You **must** annotate the additional objects for each script you mark. If no credit is to be awarded for the additional object, please use a suitable annotation (either ^ or SEEN).

MARK SCHEME

Question	Answer	Mark	Guidance
1 a	*Any one from*: 1. Breathing equipment / gas mask / respirator / oxygen mask because CO / CH_3OH / reaction mixture is toxic. 2. Fire-proof clothing because CO / H_2 / CH_3OH / reaction mixture is flammable. 3. Gloves / protective clothing because CH_3OH can be absorbed through the skin. 4. Eye protection because CH_3OH damages eyes / CH_3OH irritates eyes / CH_3OH causes blindness. 5. Flack jacket *AW* because Hydrogen is explosive. ✓	1	**MP 1, 2 & 3**: Both the protection method **and** reason (which must state 'reaction mixture' or name a specific chemical) are needed for the mark in each case. **MP1: DO NOT ALLOW** just 'mask' or 'face mask'. **ALLOW** 'breathing mask' for 'breathing equipment'. **ALLOW** 'poisonous' for toxic, but **NOT** harmful, dangerous, etc. **MP3: ALLOW** lab coat, apron or other equivalent named item of clothing. MP4: **ALLOW** goggles, safety glasses, etc.

1	**b**	Rate of forward reaction = rate of back reaction **OR** reactants and products are formed at the same rate. ✓ Concentrations remain constant / concentrations remain the same / concentrations stay the same. *AW* ✓	**2**	**DO NOT ALLOW** 'concentrations **are** the same' or 'concentrations are equal'. **DO NOT ALLOW** 'concentrations of reactants remain constant' or 'concentrations of products remain constant' on their own (i.e.: it must be clear that all concentrations are fixed, not just those on one side of the equilibrium). **IGNORE** references to closed system and steady state.
1	**c**	Fewer moles on right-hand side / fewer moles on products side /fewer moles on methanol side (*ORA*). ✓ Forward reaction is exothermic *AW* (*ORA*). ✓	**2**	**ALLOW** fewer particles **OR** fewer molecules in place of fewer moles. **DO NOT ALLOW** fewer atoms. **DO NOT ALLOW** answers that just give 'reaction is exothermic' or 'forward reaction has ΔH negative'.
1	**d**	1. Using a high pressure is too expensive. ✓ 2. Low temperature makes the process slow / low temperature makes reaction rate low. ✓	**2**	Must be clear which condition is being explained (e.g.: not just 'too expensive and too slow') Mark independently. **MP1: ALLOW** high pressures are a safety risk **OR** high pressure is too dangerous. **MP2: DO NOT ALLOW** 'expensive to use high pressure and temperature'. **DO NOT ALLOW** 'low temperatures make the process slow', if response also states 'low temperatures are expensive and/or difficult to maintain'. AW

1 e	Δ*H* with downward arrow **AND** products labelled with products below reactants ✓ Two curves drawn from the reactants line to the products line, with one having a higher maximum than the other ✓ Arrows drawn upwards from reactants line to maximum of curve and labelled as Ea and Ec, as below ✓  	**3**	**DO NOT ALLOW** a double headed arrow. Ec curve can be drawn with a double 'hump' as long as Ec is indicated as being from the reactant line to the highest point of the curve. ***For all three arrows:*** It must be clear from the diagram what the energy difference is that the arrows are marking. So, the arrows must start from (or very close to) reactants line and end as closely as possible to the maximum height of the curves, for Ea and Ec, or a close to being level with the reactants, for ΔH. Mark independently.
1 f	Provides large surface area **OR** increases surface area OR maximises surface area **OR** less catalyst needed *AW* ✓	**1**	**NOT** 'high' for large. **IGNORE** references to cost
1 g	1. Hydrogen bonding ✓ 2. Lone pair on oxygen ✓ 3. (bonds to) δ+ hydrogen of another molecule ✓	**3**	**MP2: NOT** 'lone pair on oxygen molecule'. **MP3: NOT** 'δ+ hydrogen molecule' **MP3: ALLOW** 'partial positive' or 'slightly positive' for δ+. **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. **MP3**: Award this mark if response gives 'δ+ hydrogen bonds to lone pair on another molecule'.

1	**h**	**i**	3200 – 3640 (cm^{-1}) **AND** O–H ✓	**1**	**ALLOW** one number between 3200 and 3640 or any range within these numbers. **ALLOW** 'OH', but **DO NOT ALLOW** '–OH' (i.e.: it must be clear that the bond is between the O and the H and not the one that joins the OH group to the molecule). **ALLOW** C–H at 2850 – 2950 **ALLOW** C–O at 1050 – 1300
1	**h**	**ii**	Used to identify a compound **OR** distinguish between isomers **OR** distinguish between compounds with the same functional groups. ✓	**1**	**ALLOW** to distinguish between different alcohols, or named alcohols. **ALLOW** 'molecule', 'substance', chemical', for compound, but **DO NOT ALLOW** 'element'.
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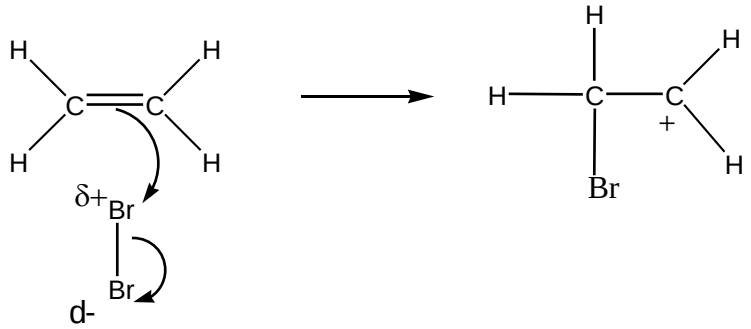
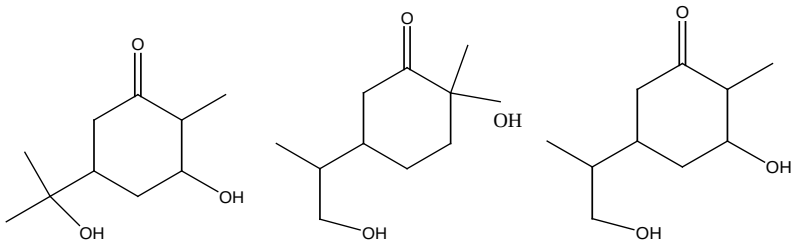
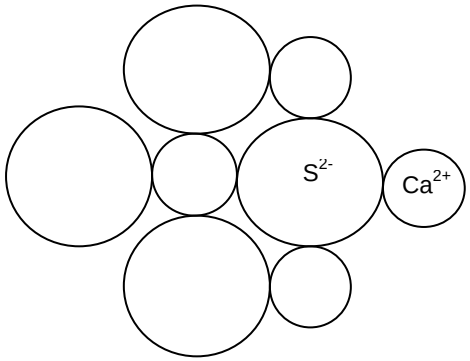
Question	Answer	Mark	Guidance
2 a	Alkene ✓	1	**ALLOW** C=C.
2 b	Boiling a liquid / mixture / chemical / solution / reactants *AW* ✓ With a vertical / upright condenser **OR** allowing liquid to drop back into the flask **OR** without liquid boiling away **OR** prevent loss of products (and/or reactants) ✓	2	**ALLOW** descriptions of boiling, such as 'heat a mixture until it vaporises'. **ALLOW** 'no gases or vapour escape' Can be scored from a diagram showing flask and vertical condenser. **DO NOT ALLOW '**prevents evaporating' or (boiling mixture) 'in a vertical condenser'. Sealed equipment **CON**s the second mark.
2 c i	$C_{10}H_{14}O + 2Br_2 \rightarrow C_{10}H_{14}OBr_4$ 2 Br_2 ✓ $C_{10}H_{14}OBr_4$ as only product✓	2	C, H, O and Br can be in any order in the product formula. **ALLOW** 1 mark for $C_{10}H_{14}O + Br_2 \rightarrow C_{10}H_{14}OBr_2$ **ALLOW** multiples of **whole** equation (e.g.: $2\ C_{10}H_{14}O + 4\ Br_2 \rightarrow 2\ C_{10}H_{14}OBr_4$). Mark independently.

2 c ii	 One mark each for two curly arrows ✓✓ Both partial charges with δ+ closest to double bond ✓ Intermediate structure with + charge in correct place ✓	**4**	**DO NOT ALLOW** half-headed arrows but **ECF** if candidate draws two half-headed arrows to the correct positions then award one mark. Curly arrow must be drawn carefully starting from near the bond and ending on an atom or pointing to the line between C and Br. **ALLOW** cyclic bromonium ion as intermediate. **ALLOW** any clear structure for intermediate (e.g.: $CH_2BrC^+H_2$ where it must be clear + is on C). **IGNORE** anything formed from the intermediate **or** Br^- as a product and any curly arrows on the intermediate side of the equation. **ALLOW** a maximum of 3 marks if any hydrogen atoms omitted, or extra hydrogen atoms shown. **IGNORE** partial charges on the ethene molecule. If left-hand side has more than 2 curly arrows, then each extra incorrect curly arrow negates a curly arrow mark. Mark separately
2 d	1. Phosphoric acid ✓ 2. Water at high temperature **OR** water at 300°C **OR** steam ✓ **OR** 1. <u>Concentrated</u> sulfuric acid ✓ 2. Add water ✓	**2**	**IGNORE** pressure **IGNORE** concentration of phosphoric acid and inert catalyst supports such as silica. **ALLOW** any temperatures of 100°C or above. **ALLOW** 1 and 2 either way round. H_2O mark dependent on acid mark in both cases (unless any additional reagents have been given, in which case water mark only can be awarded).

2	**e**	Any two from:  One mark for each correct structure ✓✓	**2**	Can be a more structured diagram. **ALLOW** structures that show bond lines to OH groups with the line to the H rather than the O.
2	**f** **i**	Reaction mixture stays orange / no colour change ✓ Tertiary alcohols are not oxidised / C=O is not oxidised **OR** Tertiary alcohols do not react / C=O does not react✓	**2**	**IGNORE** an incorrect colour if 'no colour change' or 'stays (wrong colour)' is also given. **IGNORE** references to ketones **NOT** just 'no change' or 'no reaction'. **DO NOT ALLOW** 2nd mark if referring to secondary or primary alcohol. **ALLOW** tertiary OH or description of a tertiary alcohol for 'tertiary alcohol'.
2	**f** **ii**	Loss of a molecule from a compound / one molecule becomes two / one reactant forms two products ✓ forming an unsaturated compound ✓	**2**	**ALLOW** for 1st mark: clear description of a specific elimination reaction (e.g.: water is lost from a molecule **OR** molecule is dehydrated **OR** molecule has hydrogen and oxygen atoms removed, which form water). **ALLOW** forming double bonds / C=C / alkenes

2 f iii	<u>Remove water:</u> Sodium sulfate **OR** sodium sulphate **OR** Na_2SO_4, *or other salt with an anhydrous form* ✓ <u>Separate carvone and compound A:</u> Distillation ✓	**2**	**ALLOW** silica gel (but not just silica); sodium carbonate; calcium chloride; magnesium chloride; copper sulfate (this is only a selection of suitable responses). **IGNORE** calcium carbonate and sodium hydrogencarbonate and conc sulphuric acid. **IGNORE** fractional **ALLOW** chromatography
		19	

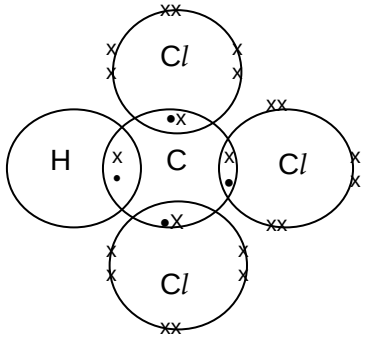
Question	Answer	Mark	Guidance
3 a i	$1s^2 2s^2 2p^6 3s^2 3p^6$ ✓	1	**ALLOW** upper or lower case letters but numbers must be superscripts **ALLOW** [Ne] $3s^2 3p^6$
3 a ii	Ca^{2+} (aq) + S^{2-} (aq) → CaS (s) Equation ✓ State symbols ✓	2	Completely correct equation (i.e.: without spectator ions) scores the first mark. **ALLOW** answer with multiples. Mark state symbols separately – must have the idea of (aq) + (aq) → (s) Mark independently. (Equations like: $CaCl_2$ (aq) + S^{2-} (aq) → CaS (s) + $2Cl^-$ (aq) score 1 mark for correct state symbols on the appropriate species).
3 a iii	 1. Smaller circles labelled Ca^{2+} and larger circles labelled S^{2-} ✓ 2. At least one more large circle correctly drawn, to show ions alternate ✓ 3. At least one small circle surrounded by 4 large circles ✓	3	**IGNORE** particles shown in other layers. **MP1: ALLOW** ecf from (a)(ii) **MP1**: **DO NOT ALLOW** mark if diagram includes electrons **OR** if *any* circles are incorrectly labelled. . **MP1**: **ALLOW** positive ions labelled 'calcium' and negative ions labelled 'sulphide'. **MP2**: **DO NOT ALLOW** if large circles are in contact with each other. Mark independently. **IGNORE** any overlap between small and large circles.

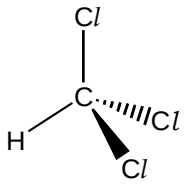
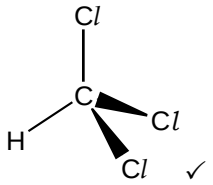
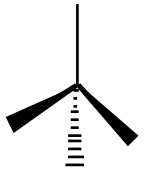
3	**b**	**i**	(15.70 x 0.0250 ⁄ 1000) = 0.0003925 ✓	**1**	**ALLOW** standard form: 3.925×10^{-4} ALLOW 0.000393 or 0.00039
3	**b**	**ii**	Answer to (b) (i) ✓	**1**	**ALLOW** answer to (b) (i) that has been rounded.
3	**b**	**iii**	Answer to (b)(ii)/40 ✓ x 1000 and evaluated (= 0.0098125) ✓ Correct evaluation of candidates calculation to 3sf (=0.00981) ✓	**3**	Correct answer on its own (i.e.: no working shown) scores all three marks – even if answer to (b)(ii) is incorrect. **ALLOW** sf mark for an answer that is the correct 3sf value of any shown calculation.
3	**c**	**i**	$Li (g) \rightarrow Li^+ (g) + e^-$ Equation **with** correct state symbols ✓	**1**	**ALLOW** e without a sign for the electron symbol **OR** $^{0}_{-1}e$ **ALLOW** $Li (g) - e^- \rightarrow Li^+ (g)$ **IGNORE** state symbol on electron **DO NOT ALLOW** capital 'G' for state symbol. **DO NOT ALLOW** multiples of the equation.
3	**c**	**ii**	Outer Li electron is closer to the nucleus (ORA) **OR** Outer Li electron has less shielding (ORA) **OR** Outer Li electron has fewer electron shells (between it and the nucleus) *AW* (*ORA*) ✓ <u>Nuclear</u> attraction (to electron) is stronger / pull from the <u>nucleus</u> (to electron) is stronger / pull from the <u>nuclei</u> (to electron) is stronger *AW* (*ORA*) ✓	**2**	Both need to be a comparison. **IGNORE** 'molecule' **ALLOW** 'it' for lithium. **ALLOW** descriptions of 'outer', such as 'outermost', 'furthest from nucleus', 'in highest energy level'. Nucleus / nuclear / nuclei must be correctly spelled at least once for the second mark to be awarded (with tick on correct spelling, not on pencil icon). Mark separately.

3 d	1.7% = 17000 ppm ✓ 17000/400 = 42.5 times more concentrated ✓ **OR** 400ppm = 0.04% ✓ 1.7/0.04 = 42.5 times more concentrated ✓	**2**	**ALLOW** 2 or more sf **ALLOW** ecf for second mark. Answer alone scores 2 marks without any reference to working (if any)
3 e	1. The temperature is higher **OR** water is hotter ✓ 2. Particles have more <u>kinetic</u> energy ✓ 3. There are more frequent successful <u>collisions</u> **OR** there are more frequent effective <u>collisions</u> ✓ **OR** Greater proportion of <u>collisions</u> has total energy of at least the activation enthalpy **OR** greater proportion of <u>collisions</u> is successful.	**3**	**ALLOW** reverse argument throughout. **IGNORE** answers in terms of concentrations. **1. ALLOW** 'warmer' for 'hotter'. **ALLOW** 'give out heat'. **2. ALLOW** 'ions' or 'molecules' for particles, but **IGNORE** 'reactants have more kinetic energy' and **IGNORE** 'bonds have more kinetic energy'. **ALLOW** particles move faster. **3. ALLOW** 'more frequent <u>collisions</u> with energy greater than activation energy' but idea of frequency (not just 'more') must be there. **DO NOT ALLOW** 'greater chance of collisions'. **DO NOT ALLOW** just 'more' for greater proportion' Answer must be in terms of the collision, not the particles (e.g.: not 'more particles have energy greater than activation energy when they collide').
		19	

Question	Answer	Mark	Guidance
4 a	1,1,2-trichloro-1,2,2-trifluoroethane Trichlorotrifluoroethane ✓ 1,1,2 and 1,2,2 ✓	2	**IGNORE** commas, dashes and spaces. **ALLOW** minor spelling errors, such as 'flouro'. Mark independently. **ALLOW** 1,2,2-trichloro-1,1,2-trifluoroethane for 2 marks **ALLOW** 1,1,2-trifluoro-1,2,2-trichloroethane **OR** 1,2,2-trifluoro-1,1,2-trichloroethane for 1 mark.
4 b i	C-Br ✓	1	**ALLOW** answer in words. **DO NOT ALLOW** 'the bromine bond' **OR** 'the Br bond'.
4 b ii	Visible / ultraviolet / UV ✓	1	

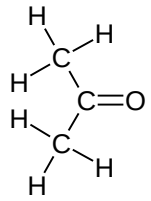
4	b	iii	*CALCULATION A: Energy to break one bond:* (290 / 6.02 x 10^{23}) ✓ x 1000 (= 4.817 / 4.82 / 4.8 x 10^{-19} J) ✓ *CALCULATION B:Minimum frequency to break one bond* Candidate value for energy in J / 6.63 x 10^{-34} and evaluate (= 7.266 / 7.27 / 7.3 x 10^{14} Hz) ✓ *CALCULATION C: Energy of one photon* 6.63 x 10^{-34} x 5.3 x 10^{14} (=3.514 / 3.51 / 3.5 x 10^{-19} J) ✓ *CALCULATION D: Energy of one mole of photons* Candidates value for energy in J / 1000 ✓ x 6.02 x 10^{23}) and evaluate (= 211.5 / 211 / 210 kJ mol^{-1}) ✓ **Will bond break?** *Response has A and B:* Candidates answer > 5.3 x 10^{14} Hz: bond does not break because frequency of radiation/energy is less than that needed to break bond. (*ORA*) ✓ *Response has C and D:* Candidates answer < 290 kJ mol^{-1}: bond does not break because radiation has energy/ frequency less than that needed to break bond. (*ORA*) ✓ *Response has A and C (with C evaluated):* Energy to break one bond > energy of one photon, so bond does not break. (ORA) ✓	4	**IGNORE** sig figs. A completely correct answer to the calculation on its own scores 3 marks. **IGNORE** evaluations at the end of intermediate steps in the calculation. In B and D, allow candidate value from previous part of working to any number of sf. **DO NOT ALLOW** mark for explanation if no calculation has been attempted. **ALLOW** ecf for explanation mark from incorrect calculation that shows bond will break (e.g.: candidate's calculated value for energy or frequency of radiation is greater than bond energy).

4 c	1. <u>Both</u> (*AW*) form chlorine radicals *AW* **OR** UV can break C-C*l* bonds in <u>both</u> ✓ 2. CFC-113 can form <u>more</u> (chlorine) radicals **OR** CFC-113 has <u>more</u> C*l* / CFC-113 has <u>more</u> C-C*l* bonds✓ 3. Chlorine radicals <u>catalyse</u> the breakdown of ozone ✓	**3**	**ALLOW** chlorine atoms or C*l* for chlorine radicals. **MP1 & MP2: IGNORE** halogen radicals and Br radicals and F radicals. MP2: **ALLOW** 'chlorines' or 'chlorine' for C*l* MP3: **ALLOW** mark if response refers to halogen radicals or F or Br radicals rather than C*l* radicals.
4 d	Chlorine: Toxic / poisonous / causes respiratory diseases ✓ Methane: Greenhouse gas / causes global warming / causes greenhouse effect ✓	**2**	**IGNORE** harmful / irritant / dangerous / breathing problems / comments about ozone breakdown..
4 e	 All correct for one mark ✓	**1**	Any two ***different*** symbols can be used to represent the bonding electrons. Candidate does not have to draw circles for electron shells.

4 f	 (change dotted wedge to dotted line) OR  ✓ Bond angle 109º ✓	**2**	**ALLOW** other 3-D representations of the molecule. **ALLOW** hydrogen in any position. Diagram needs to be as shown on the left or one bond in the plane, with two coming out of the plane of the page and one going in (or vice versa) - like this, but with atoms labelled:  If two bonds are shown in the same plane, they must be next to each other (i.e.: not two lines in the same plane at 180° to each other). **ACCEPT** bond angle values in the range 107 – 111 º **DO NOT ALLOW** diagram mark if molecule is incorrect.

4 g	(a) Earth absorbs uv **and** radiates ir ✓ (b) CHCl_3 molecules absorb ir ✓ (c) bonds vibrate ✓ (d) vibrational energy becomes KE / increase in vibrational energy increases KE **OR** KE becomes thermal energy **OR** molecules radiate ir ✓ *QWC for connection of ideas:* *Linking absorbing ir with MP(c)* *or* *linking absorbing ir with MP(d)* ✓	**4** **1**	(a) **ALLOW** 'emits' or 'gives out' for radiates, but **DO NOT ALLOW** reflects. (b) **ALLOW** 'molecules' for CHCl_3 (but not 'it', unless clearly in the context of CHCl_3). (c) **ALLOW** this for answers suggesting other radiations are absorbed by the CHCl_3. Also, **ALLOW** 'increases vibrational energy of bonds or molecules'. (d) **ALLOW** 'emits' or 'gives out' for radiates. **ALLOW** 'heat' for thermal energy'. **Please indicate QWC mark using red cross or green tick on the right of the pencil icon on the answer screen.**
4 h i	*Two from:* Models of the atmosphere and the models' temperatures ✓ Computer models of the atmosphere's composition and temperature ✓ Temperature and concentration data from the atmosphere ✓	**2**	

4 h ii	As <u>concentration</u> of greenhouse gases increases, atmospheric <u>temperatures</u> increase. *AW*	**1**	**DO NOT ALLOW** just 'atmosphere gets warmer' for temperature increases and **DO NOT ALLOW** 'level' for concentration. **IGNORE** increase in concentration of greenhouse gases **causes** increase in temperature. **ALLOW** answers in terms of <u>positive</u> correlation
4 i	*Advantage:* They are broken down in the troposphere/they do not reach the stratosphere ✓ *Disadvantage – **one** of:* (they are also) greenhouse gases / global warming gases **OR** more expensive **OR** form HF ✓	**2**	If the response does not state which is the advantage and which the disadvantage, assume the advantage comes first and the second is the disadvantage. **IGNORE** less effective
		26	

Question	Answer	Mark	Guidance
5 a i	 ✓	1	Diagram must show all atoms and all bonds.
5 a ii	Ketone ✓	1	**ALLOW** carbonyl. **ALLOW** minor spelling errors, such as 'keytone'.
5 b	Electrophilic addition ✓	1	
5 c i	Carbocation ✓	1	**ALLOW** 'carbonium ion'.
5 c ii	100% ✓	1	Answer must be a percentage and not just a number.
5 d	High temperature <u>and</u> high pressure ✓ Platinum ✓	2	**ALLOW** temperatures 100-200^0 and pressures >1≤10atm **ALLOW** high temperature and pressure **ALLOW** answers in either order. **IGNORE** conditions for platinum catalyst.

5	**e**	*Any 3 from*: 1. One uses only 2-methlypropene and the other uses 2-methylpropene and 2-methylpropane ✓ 2. Catalysts are different **OR** one uses HF, the other uses H_2SO_4 **OR** one uses HF, the other uses Ni 3. One uses one catalyst, the other uses two✓ 4. The processes have different number of steps. ✓ 5. One uses a heterogeneous catalyst and the other a homogeneous catalyst ✓ 6. One uses high temperatures and pressures, the other doesn't need them. ✓	**3**	Answers must be comparisons. **MP1: ALLOW** one has one organic reactant, the other has two **OR** one uses 2-methylpropene, the other uses 2-methylpropane. **MP2: DO NOT ALLOW** 'one uses H_2SO_4, the other uses Ni'. **MP5: ALLOW** one has reactants in same phase as catalyst; the other has reactants in different phase from catalyst. **IGNORE** comments about intermediates.
5	**f**	Poly(phenylethene) ✓	**1**	**ALLOW** 'poly(styrene)' or 'poly phenylethene'
5	**g** **i**	A bond breaks so that each new particle has one of the bonding electrons **OR** bond breaks forming two new particles each with an unpaired electron *AW* **OR** Homolytic fission ✓	**1**	**ALLOW** homolysis

5	g	ii	$R\text{-}O^{\bullet} + H_2C{=}CHCH_3 \rightarrow RO\text{-}CH_2\text{-}CHCH_3^{\bullet}$ ***OR*** $RO\text{-}CH_2\text{-}CHCH_3^{\bullet} + H_2C{=}CHCH_3 \rightarrow RO\text{-}CH_2\text{-}CHCH_3\text{-}CH_2\text{-}CHCH_3^{\bullet}$ ***OR*** $R\text{-}O^{\bullet} + CHCH_3{=}CH_2 \rightarrow RO\text{-}CHCH_3\text{-}CH_2^{\bullet}$ ***OR*** $RO\text{-}CHCH_3\text{-}CH_2^{\bullet} + CHCH_3{=}CH_2 \rightarrow RO\text{-}CHCH_3\text{-}CH_2\text{-}CHCH_3\text{-}CH_2^{\bullet}$	**1**	Allow other structural representations of the species. Allow any equation of the form: $RO\text{-}(CH_2\text{-}CHCH_3)_n^{\bullet} + H_2C{=}CHCH_3 \rightarrow RO\text{-}(CH_2\text{-}CHCH_3)_{n+1}^{\bullet}$ **OR** $RO\text{-}(CHCH_3\text{-}CH_2)_n^{\bullet} + CHCH_3{=}CH_2 \rightarrow RO\text{-}(CHCH_3\text{-}CH_2)_{n+1}^{\bullet}$ where n is an integer (if written out in more detail, check sequence of CH_2 then $CHCH_3$ correct) **ALLOW** responses without the 'dot' for the unpaired electron or incorrectly positioned 'dots'.

5 h	*1. <u>One property for each, taken from:</u>* Atactic: soft / rubbery / flexible Isotactic: strong / hard / rigid / excellent resistance to stress / excellent resistance to cracking. ✓ 2. Both have instantaneous (dipole) – induced dipole bonds. ✓ *<u>Explanation:</u>* 3. Isotactic chains are stereoregular (ORA) **OR** atactic has methyl groups randomly oriented **OR** isotactic has all methyl groups in same orientation ✓ 4. Atactic chains cannot pack as closely (ORA) / atactic chains have less surface contact (ORA) ✓ 5. which leads to atactic having weaker (intermolecular) bonds (ORA) ✓ 6. so less energy is needed to break (intermolecular) bonds in atactic (ORA) **OR** less force is needed to break (intermolecular) bonds in atactic (ORA) **OR** chains of atactic slide over each other more easily (ORA) **OR** less force is needed to make atactic chains slide over each other (ORA) ✓ ***QWC** for showing clearly* *that the process from mp5 follows from the process in mp4* ***OR** that the process from mp6 follows from mp5* ✓	**6** **1**	**Please use annotations on answer in appropriate place** One mark for <u>both</u> properties. **ALLOW** atactic is softer (ORA), **OR** atactic is more flexible (ORA) **OR** atactic is less dense (ORA) **OR** atactic has a lower Tm **or** Tg (ORA) (must be a comparison). **MP2: ALLOW** van der Waals. MP3**: ALLOW** 'branches' for 'methyl groups'. MP3: **IGNORE** 'stereochemical' and 'regular' for stereoregular. MP4: **DO NOT ALLOW** just 'don't fit together easily / less easily' (ora) MP5: **ALLOW** less/fewer intermolecular bonds / attractive forces can form between atactic chains (ora) / attractive forces are weaker between atactic chains (ora) MP6: Answer must be a comparison. **Please indicate QWC mark using red cross or green tick onto the right of the pencil icon on the answer screen.**
		20	

APPENDIX 1

Use this space for a generic mark scheme grid that applies across the question paper

APPENDIX 2

Use this space if you have extensive subject specific information that is inappropriate to include in section 10 page 3.

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