



General Certificate of Education

Chemistry (5421)

CHM3/W Introduction to Organic Chemistry

Mark Scheme

2008 examination - January series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

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Question 1

- (a) (i) Fractional distillation OR fractionation 1
- concs not allowed*
"cracking"
Not distillation
reasonable spelling
- (ii) Compounds/mixtures/alkanes/hydrocarbons with a boiling point range
 OR similar boiling points OR similar chain length. 1
- (b) Contain single carbon-carbon bonds only 1
- (c) (i) $\text{C}_{10}\text{H}_{22} + 10\frac{1}{2}\text{O}_2 \longrightarrow 10\text{CO} + 11\text{H}_2\text{O}$ 1
- (credit double this equation)*
- (ii) Carbon OR soot(y deposits) OR C 1
- (iii) Sulfur dioxide OR SO_2 1
- Not SO_3*
Not SO
- (d) (i) $\text{CH}_3\text{OH} + 1\frac{1}{2}\text{O}_2 \longrightarrow \text{CO}_2 + 2\text{H}_2\text{O}$ 1
- (credit double this equation)*
- (ii) Petroleum is finite OR sugar is renewable 1

Total 8**Question 2**

- (a) (i) C_nH_{2n} or C_xH_{2x} ONLY 1
- Formula - carbon/hydrogen*
Not C_2H_4 but C_2H_{4n} OK
- (ii) Any TWO from 2
- Gradation/trend/gradual change in physical properties/
specified physical property.
 - Each member differs by CH_2 from the last.
 - Chemically similar OR react in the same/similar way OR
same chemical properties.
 - Same functional group
- (Penalise "same molecular formula" OR "same empirical formula")*
(Do not credit references either to "same properties" or "different properties" unless it is clear that these are referring correctly either to chemical or physical properties respectively)

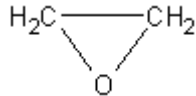
(b)	C ₆ H ₁₂ ONLY Not C ⁶ H ¹²	1
(c)	CH ₃ CH=CHCH ₂ CH ₃ <i>(Structure can be like this or drawn out – possibly as cis or trans isomer. Give credit for a correct structure for pent-2-ene.)</i>	1
(d)	(i) The empirical formula shows the <u>simplest</u> whole number <u>ratio of atoms</u> of each <u>element/type</u> in the compound/formula/molecule.	1
	(ii) C ₂ H ₃ ONLY <i>Not C²H³ anything else is wrong</i>	1
(e)	(i) TWO ideas <ul style="list-style-type: none"> Double bonds are <u>electron-rich/electron pair donors/centres of electron density</u>. Bromine <u>becomes polarised</u> OR has an <u>induced dipole</u>. 	2
	(ii) Electrophilic addition ONLY <i>(Both words) Spelling mistakes OK. With a 'y' is possible</i>	1
	(iii) CH ₂ BrCHBrCHBrCH ₂ Br <i>(Structure can be like this or drawn out. Give credit for a correct structure for 1,2,3,4-tetrabromobutane)</i>	1

Total 11**Question 3**

(a)	(i) Compounds with the <u>same structural formula</u> (M1) but with <u>atoms/bonds/groups</u> arranged <u>differently in space</u> OR with <u>different spatial arrangements</u> . (M2) <i>(Penalise M1 if "same structure") (Ignore references to "same molecular formula")</i>	2
	(ii) Geometric(al) OR cis-trans (stereoisomerism) ONLY <i>both 'cis' + 'trans' E-Z</i>	1
(b)	(i) Reduction OR hydrogenation ONLY OR Addition (of hydrogen)	1

(ii)	Reagent: H ₂ OR hydrogen (gas)	1
	Catalyst: Ni OR Nickel OR Pd OR Palladium (penalise incorrect state symbol, but otherwise ignore)	1
	Not H Not solid (s) or liquid (l) Mark independently	
(c)	Primary (alcohol) OR 1° (alcohol) ONLY	1
(d)	Type of reaction: Oxidation OR Redox ONLY	1
	Reagent: Acidified K ₂ Cr ₂ O ₇ OR acidified potassium dichromate OR H ₂ SO ₄ /K ₂ Cr ₂ O ₇ OR names of these <u>two</u> reagents	1
	(penalise incomplete reagent e.g. "dichromate" OR acidified dichromate") (If oxidation state is given, it must be correct, otherwise ignore) (If formula is given it must be correct) (Ignore reference to concentrated, dilute, aqueous) (Accept any other correct acid)	

Total 9**Question 4**

(a)	Equation: 2NO + 2CO → N ₂ + 2CO ₂	1
	Catalyst: Platinum (or Pt) OR Palladium (or Pd) OR Rhodium (or Rh)	1
(b)	Correct structure for epoxyethane showing correct bonds between C—O and C—C	1
		
	Catalyst: Ag OR Silver OR silver-based	1
(c)	Equation: C ₁₂ H ₂₆ → C ₆ H ₁₂ + C ₆ H ₁₄	1
	Catalyst: Zeolite OR aluminosilicate	1
(d)	Equation: C ₆ H ₁₂ O ₆ → 2CH ₃ CH ₂ OH + 2CO ₂	1
	Catalyst: Yeast OR suitable enzyme (zymase)	1
	(The ethanol can be C ₂ H ₅ OH but NOT C ₂ H ₆ O)	

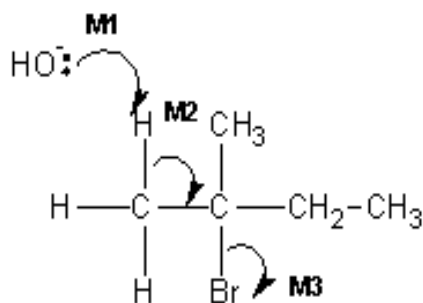
- (e) Equation: $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \longrightarrow \text{CH}_3\text{CH}_2\text{CH}=\text{CH}_2 + \text{H}_2\text{O}$ 1
- Catalyst: Concentrated H_2SO_4 OR Concentrated H_3PO_4 OR Al_2O_3 1
- (The structure of the butan-1-ol and but-1-ene must be obvious)

Total 10**Question 5**

- (a) Initiation: $\text{Br}_2 \longrightarrow 2\text{Br}\cdot$ 1
- First propagation:
 $\text{Br}\cdot + \text{CH}_3\text{Br} \longrightarrow \cdot\text{CH}_2\text{Br} + \text{HBr}$ 1
- Second propagation:
 $\text{Br}_2 + \cdot\text{CH}_2\text{Br} \longrightarrow \text{CH}_2\text{Br}_2 + \text{Br}\cdot$ 1
- (b) (i) $\text{CH}_3\text{Br} + 3\text{Br}_2 \longrightarrow \text{CBr}_4 + 3\text{HBr}$ 1
- (ii) Use excess bromine/ Br_2 1
- (c) In the equation: 2NH_3 and CH_3NH_2 1
- Name of product: methylamine 1
- (Accept "aminomethane" as an alternative name)

Total 7**Question 6**

- (a) A 2-bromo-2-methylbutane 1
- B 2-methylbut-1-ene 1
- C 2-methylbutan-2-ol 1
- (b) Elimination 1



3

M1 must show an arrow from the lone pair on oxygen to the correct H atom

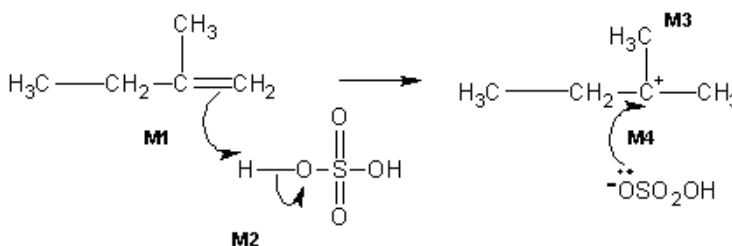
M2 must show an arrow from the correct C-H bond to the correct C-C bond and should only be awarded if an attempt has been made at M1

M3 is independent.

Award full marks for an E1 mechanism in which M2 is on the correct carbocation.

(c) Electrophilic addition

1



4

M1 must show an arrow from the double bond towards the H atom of the O-H bond OR this could be to an H⁺ ion.

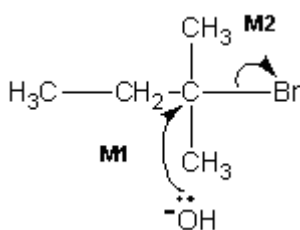
M2 must show the breaking of the O-H bond.

M3 is for the structure of the tertiary carbocation.

M4 must show an arrow from the lone pair of electrons on the oxygen of the negatively charged ion towards the positively charged carbon atom.

(d) Nucleophilic substitution

1



2

M1 must show an arrow from the lone pair of electrons on the oxygen atom of the negatively charged hydroxide ion to the central C atom.

M2 must show the movement of a pair of electrons from the C-Br bond to the Br atom.

Mark M2 independently.

Award full marks for an S_N1 mechanism in which M1 is the attack of the hydroxide ion on the intermediate carbocation.

Total 15