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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Chemistry 5421

CHM3/W Introduction to Organic Chemistry

Mark Scheme

2006 examination - June 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.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

CHM3/W

SECTION A

Question 1

(a) hydration OR (electrophilic) addition 1
(penalise incorrect words in front of the word "addition" e.g. "nucleophilic")
(penalise "indirect hydration" but credit "direct hydration" or "steam hydration")

$H_2C=CH_2 + H_2O \longrightarrow CH_3CH_2OH$ 1
(ignore state symbols)
(credit use of C_2H_5OH for ethanol)
(penalise use of C_2H_6O for ethanol on the first occasion)
(credit C_2H_4 and $CH_2=CH_2$ for ethene)
(penalise CH_2CH_2, $CH_2{\bullet}CH_2$, $CH_2{:}CH_2$ for ethene on the first occasion)
(ignore H_2SO_4 OR extra H_2O OR H^+ if it appears on both sides)

conc. H_2SO_4 OR conc. H_3PO_4 1

(b) (i) Carbon OR C 1
(credit "soot" or "sooty")
(penalise "coke" or "coal")
(credit "carbon + carbon monoxide" provided it is clear that carbon is solid; penalise "carbon + carbon dioxide")

(ii) $CH_3CH_2OH + O_2 \longrightarrow 2C + 3H_2O$ 1
OR
$CH_3CH_2OH + 1½O_2 \longrightarrow C + CO + 3H_2O$
(credit multiples of these equations)
(credit use of C_2H_5OH for ethanol)
(penalise use of C_2H_6O for ethanol, but note a possible repeat error from part (a) above)

Total 5

Question 2

(a) $CH_3CH_3 \longrightarrow H_2C=CH_2 + H_2$ 1
(credit C_2H_6 for ethane)
(credit C_2H_4 and $CH_2=CH_2$ for ethene)
(penalise CH_2CH_2, $CH_2{\bullet}CH_2$, $CH_2{:}CH_2$ for ethene, but check Q1(a) for possible repeat error)

(b) (i) M1 curly arrow from lone pair of electrons on oxygen of hydroxide ion — 1
(insist on a lone pair of electrons on the oxygen atom and a negative charge, but only credit this mark if the attack is to a correct H atom)
M2 curly arrow from the middle of the C-H bond to the middle of the C-C bond. — 1
(only credit this mark if the arrow originates from the correct C-H bond and if an attempt has been made at M1)
M3 curly arrow from the middle of the C-Br bond towards/alongside the Br atom. — 1
(credit M3 independently unless the bond breaking is contradicted by an additional arrow)
(penalise M3 curly arrow if the C-Br has a formal positive charge)
(ignore partial charges on the C-Br bond, but penalise if incorrect)

(credit full marks for an E1 mechanism, with M2 awarded for a correct curly arrow on the correct carbocation)
(award a maximum of two marks for an incorrect haloalkane)
(ignore products)

(ii) Haloalkane/C_2H_5Br is made from ethene — 1
OR haloalkane is not (readily) available
OR haloalkane is expensive
OR it is (too) expensive/costly
OR (reaction) yield is too low/poor
OR it is too slow
OR a valid reference to nucleophilic substitution/alcohol formation occurring as an alternative reaction.
(ignore references to temperature or to energy consumption)
(do not credit statements which refer to the idea that this route is not chosen, because industry chooses another route e.g. cracking)

(c) (i) Strained ring/ bonds/ structure/molecule — 1
OR three-membered ring
OR 60^o bond angle
OR bond angle much less than tetrahedral
(penalise "stressed ring")
(ignore "weak bonds", ignore "unstable")

(ii) ethane-1,2-diol OR correct structure — 1
(penalise ethylene glycol OR 1,2-dihydroxyethane if these appear alone)
(credit ethan-1,2-diol)
(If both a structure and a formula are given, credit either correct one of these provided the other is a good, if imperfect, attempt)

(used in) antifreeze — 1
OR
for OR in the manufacture/making/formation of terylene, polyester,

PET only
(ignore reference to terylene etc. if they accompany "antifreeze")
(penalise "de-icer", "solvent", "surfactant", "plasticizer")
(If the candidate indicates that the product is antifreeze ,then this can gain credit, but not if contradicted in its use e.g. as de-icer)

Total 8

Question 3

(a) (i) (free-)radical substitution 1
(both words required for the mark)

(ii) uv light OR sunlight OR high temperature OR 150°C to 500°C 1

(iii) Propagation 1
(ignore "chain", "first", "second" in front of the word propagation)

(iv) Termination 1
$\bullet CH_2CH_3 + Br\bullet \longrightarrow CH_3CH_2Br$ 1
OR $2\bullet CH_2CH_3 \longrightarrow C_4H_{10}$
(penalise if radical dot is obviously on CH_3, but not otherwise)
(penalise $C_2H_5\bullet$)
(credit $2Br\bullet \longrightarrow Br_2$)
(ignore "chain" in front of the word termination)

(b) (i) Fractional distillation OR fractionation 1
(credit gas-liquid chromatography, GLC)

(ii) $CH_3CH_3 + 6Br_2 \longrightarrow C_2Br_6 + 6HBr$ 1
(credit C_2H_6 for ethane)

(c) Correct structure for CF_2BrCF_2Br drawn out 1
(penalise "Fl" for fluorine)

(d) (i) 2-bromo-2-chloro-1,1,1-trifluoroethane 1
OR 1-bromo-1-chloro-2,2,2-trifluoroethane
(insist on all numbers, but do not penalise failure to use alphabet)
(accept "flourine" and "cloro" in this instance)

(ii) 197.4 only 1
(ignore units)

(iii) (57/197.4 x 100) = 28.9% OR 28.88% 1
(credit the correct answer independently in part (d)(iii), even if (d)(ii) is blank or incorrectly calculated, but mark consequential on part (d)(ii), if part (d)(ii) is incorrectly calculated, accepting answers to 3sf or 4sf only)

(penalise 29% if it appears alone, but not if it follows a correct answer)
(do not insist on the % sign being given)
(the percentage sign is not essential here, but penalise the use of units e.g. grams)

Total 11

Question 4

(a) (i) M1 (compounds with) the same molecular formula *(OR this could be defined)* 1
M2 but different structural/graphical/displayed formulas OR different structures 1

(ii) C_3H_6O only 1

(iii) CH_2 only 1

(b) potassium dichromate(VI)/$K_2Cr_2O_7$ and acid/acidified/H_2SO_4/HCl/H^+ 1
(OR $KMnO_4/H_2SO_4$, but not HCl)

(remains) orange or no change or no reaction 1
(OR (remains) purple if $KMnO_4$)

(goes or orange to) green 1
(OR (goes or purple to) colourless if $KMnO_4$ in acid and accept brown ppt. or green if neutral or in alkali)

(c)

Potassium dichromate (VI)/$K_2Cr_2O_7$ and acid/acidified/H_2SO_4/ H^+ OR *($KMnO_4/H_2SO_4$)*	Fehling's solution OR *Benedict's solution*	Tollens' reagent OR $AgNO_3/NH_3$ OR ammoniacal siver nitrate. *(penalise $AgNO_3$ alone, but mark on)*	1
(goes or orange to) green *(goes or purple to) colourless/brown ppt./green solution if $KMnO_4$ used)*	red solid *(OR yellow/green/red solid if Benedict's is used)*	silver mirror/coating/tube OR black/grey precipitate/solid	1
(remains) orange or no change or no reaction *(OR purple for $KMnO_4$)*	(remains) blue or no change or no reaction	(remains) colourless or no change or no reaction	1

(d) bromine (water) 1
OR iodine solution
OR iodine in KI
(OR $KMnO_4$)

remains yellow/orange/brown/red or no change or no reaction 1
(if $KMnO_4$, remains purple or no change or no reaction)
(goes) colourless or decolourised 1
(penalise "goes clear" and penalise "discolour")
(goes or purple to) colourless/brown ppt/green solution if $KMnO_4$ used)

In each of parts (b), (c) and (d), note the following general ideas

If no reagent then CE=0
If totally wrong reagent then CE=0
If correct reagent has been attempted, whether by formula or name, but is wrongly presented, penalise the reagent, but mark on.
If the candidate writes "nothing" as the answer to a negative response, penalise this on the first occasion and then credit RE subsequently.
If both observations are the same then give no credit for either, since this would fail to discriminate.

Total 13

Question 5

(a) (i) M1 pentan-3-one only 1
1

M2 $CH_3CH_2CH_2COCH_3$
(insist on C=O being drawn out)
(penalise use of C_3H_7)

(ii) *aldehyde* $(CH_3)_2CHCH_2CHO$ 1
1

ketone $(CH_3)_2CHCOCH_3$
(insist on a clear structure for the C=O of the functional groups, but do not be too harsh on the vertical bonds between carbon atomson his occasion)
(If both structures correct, but wrong way around, award one mark)
(ignore names)

(b) (i) $CH_3CH_2CH_2CH_2CHO + [O] \longrightarrow CH_3CH_2CH_2CH_2COOH$ 1
(accept C_4H_9CHO going to C_4H_9COOH)
(insist on a balanced equation - for example do not credit [O] over the arrow alone)

(ii) pentanoic acid 1
(credit pentan-1-oic acid)

(c) (i) $CH_3CH_2CH_2CH_2CH_2OH$ OR pentan-1-ol 1

(If both a structure and a formula are given, credit either correct one of these provided the other is a good, if imperfect, attempt)

(ii) Primary 1
(credit 1^o or 1)

Total 8

Question 6

(a) M1 (Free-)radical intermediates 1
(credit "alkyl radicals", but penalise "carbon radicals")
(penalise "radical substitution" as a contradiction)

M2 formed by <u>breaking/splitting of C-C bonds/C-H bonds/carbon chain</u> 1
OR
by <u>homolysis/homolytic fission/reaction</u>
(credit M1 and M2 independently)
(credit M2 for a correct illustration of homolysis of a C-C bond to produce radicals)
(If reference to carbocations, then CE=0 for this section)
(If "heterolytic" is referred to, then penalise M2)
(ignore conditions, including catalyst and temperature)

Sub-total 2 marks

(b) M1 curly arrow <u>from C=C bond</u> towards/alongside the side of H atom on H-Br 1
(penalise M1 if arrow to formal positive charge on HBr)
(ignore partial charges on H and Br of HBr, but penalise if these are incorrect)
(award one mark from M1+ M2 if H^+ is used, ignoring its formation)
M2 curly arrow <u>from H-Br bond</u> towards/alongside the side of the Br atom. 1
(credit the arrow even if there are partial or formal charges on H and Br)
M3 correct structure of the carbocation 1
(lose only this mark if primary carbocation is formed, then mark on)
M4 curly arrow <u>from lone pair on the bromide ion</u> towards/alongside <u>C atom</u> bearing the positive charge. 1
(insist that the bromide ion has a lone pair of electrons and a negative charge.)

(award a maximum of three marks for use of the wrong alkene)

Sub-total 4 marks

(c) M1 curly arrow <u>from lone pair</u> on nitrogen of (correct formula for) ammonia towards/alongside C atom of C-Br 1
(penalise M1 if formula of ammonia is wrong or has a negative charge or has no lone pair or arrow is not from lone pair)
M2 curly arrow <u>from C-Br bond</u> towards/alongside side Br atom 1
(credit M2 independently)

(penalise M2 if formal positive charge on C atom of C-Br)
(M2 is a possible RE from 2(b)(i)M3)

M3 correct structure of the alkylammonium ion 1

(credit the structure drawn out with all four bonds around the nitrogen atom OR written as RNH_3^+)

M4 curly arrow from the middle of one of the H-N bonds towards the (positive) N atom 1

(N.B. it is possible to credit M4 on an alkylammonium ion which is all correct except for the omission of the positive charge)
(award a maximum of three marks if the wrong haloalkane is used)
(If S_N1 mechanism is used, give full credit in which M1 is for a curly arrow from the lone pair of the N atom of (correct formula for) ammonia towards/alongside the positive carbon atom of the carbocation)

Sub-total 4 marks

(d) M1 poly(propene) OR polypropene only 1

M2 Substance P is a large molecule/macromolecule/long-chained molecule/ high M_r molecule 1
QoL
(award this mark only if there is clear reference to a large molecule)

M3 many intermolecular/Van der Waals' forces (of attraction) between molecules/chains 1
OR
the idea of large surface contact between molecules/chains (or wtte)
(penalise M3 if reference to "bonds")
(penalise M3 if the intermolecular forces are described as "strong", but credit an answer which suggests that the overall force of attraction is strengthened/increased)
(penalise M3 if the forces are described as "dipole-dipole" or "hydrogen bonds")

Sub-total 3 marks

(e) M1 electron/lone pair donor (or wtte) QoL 1
OR
a species/ molecule/ion with an electron/lone pair which can create a co-ordinate/covalent bond)
(award this mark if there is clear reference to an electron pair being donated)

M2 hydroxide ion 1
(credit reference to the formula for the hydroxide ion)

Sub-total 2 marks
Total 15