OXFORD CAMBRIDGE AND RSA EXAMINATIONS

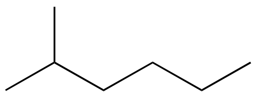
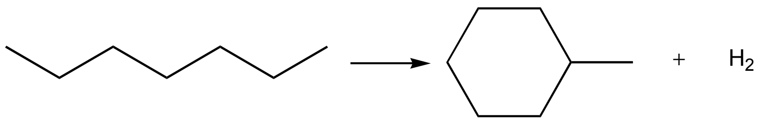
Advanced Subsidiary GCE

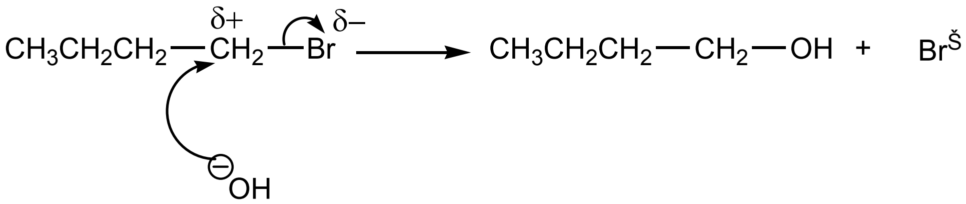
CHEMISTRY A F322 QP

Unit F322: Chains, Energy and Resources

Specimen Mark Scheme

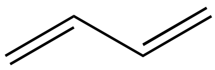
The maximum mark for this paper is **100**.

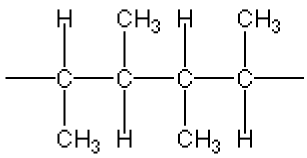
Question Number	Answer	Max Mark
1(a)(i)	120–130 ✓	**[1]**
(ii)	boiling point increases with increase in M_r/molecular formula/number of carbon atoms/chain length✓ more intermolecular forces/electrons/surface area/ surface interactions/van der Waal forces ✓	**[2]**
(b)	$C_{13}H_{28}$ ✓	**[1]**
(c)	$C_9H_{20} \rightarrow C_7H_{16} + C_2H_4$ ✓	**[1]**
(d)(i)	Any branched isomer of heptane with correct name, e.g.  ✓ 2-methylhexane ✓	**[2]**
(ii)	 ✓ ✓	**[2]**
(e)(i)	species with an unpaired electron ✓	**[1]**
(ii)	uv (light)/high temperature/min of 400 ^{o}C/sunlight✓	**[1]**
(iii)	homolytic (fission) ✓	**[1]**
(iv)	$C_4H_{10} + Cl\bullet \longrightarrow C_4H_9\bullet + HCl$ ✓ $C_4H_9\bullet + Cl_2 \longrightarrow C_4H_9Cl + Cl\bullet$ ✓	**[2]**
2(a)(i)	8.72/136.9 = 0.0637 mol ✓	**[1]**
(ii)	M_r butan-1-ol = 74(.0) ✓ moles = 4.28/74.0 = 0.0578 mol ✓	**[2]**
(iii)	0.0578/0.0637 x 100 = 90.7% ✓	**[1]**

Question Number	Answer	Max Mark
(b)(i)	substitution/hydrolysis ✓	[1]
(ii)	electron pair donor ✓	[1]
(iii)	 correct dipole ✓ curly arrow from the O in the OH- to C in the CH_2 ✓ curly arrow to show movement of bonded pair in the C–Br bond ✓ Br^- as a product ✓	[4]
(c)(i)	Any two realistic fragments, *e.g*. CH_3^+: 15; $C_2H_5^+$: 29; $C_3H_7^+$: 43; $C_4H_9^+$: 57; OH^+: 17, *etc*. ✓✓ Do not penalise missing charge.	[2]
(ii)	breathalysers/monitoring of air pollution, MOT emission testing, *etc*. ✓	[1]
3(a)	**Availability of starting materials:** availability sugar is renewable because it can be grown ✓ ethane is finite because it is obtained by processing of crude oil ✓ energy: fermentation: energy is required for distillation/ hydration: energy is required to generate steam ✓ **atom economy and waste products:** atom economy for fermentation < atom economy hydration ✓ In fermentation, CO_2 is produced in addition to ethanol/ethanol is not the only product ✓ In hydration, ethanol is the only product/hydration is an addition reaction ✓ Atom economy of fermentation could be increased by finding a use CO_2 ✓ ✎Atom economy linked to a chemical equation to show that hydration has 100% atom economy/fermentation has 51% atom economy ✓	[7max]

Question Number	Answer	Max Mark
(b)(i)	(volatile components) can escape/distil out✓ ethanal is most volatile/bpt less than 60 °C/partial oxidation✓	[2]
(ii)	(volatile components) cannot escape/ refluxed✓ complete oxidation will be achieved/oxidised to the acid ✓	[2]
(c)	$C_2H_5OH + 2[O] \longrightarrow CH_3COOH + H_2O$ C_2H_5OH, 2[O] and CH_3COOH ✓ rest of equation ✓	[2]
(d)	spectrum C: only shows absorption at 1700 cm^{-1} for the C=O✓ the other two spectra contain the OH group absorption at approx 3000 cm^{-1}✓	[2]
4(a)(i)	bond breaking is endothermic/ energy has to be put in to break a bond ✓	[1]
(ii)	bonds broken: 3(C–H) + (C–O) + (O–H) + 1.5 (O=O) = 2781 kJ ✓ bonds made: 2(C=O) + 4(O–H) = 3470 kJ ✓ $\Delta H_c = -689$ (kJ mol^{-1}) ✓	[3]
(b)(i)	(heat/energy change) when 1 mole of substance is formed ✓ from its elements ✓	[2]
(ii)	1 atm/101 kPa and a stated temperature/25 °C/298 K ✓	[1]
(iii)	$C(s) + ½ O_2(g) \rightarrow CO(g)$ balanced equation forming 1 mol CO ✓ state symbols ✓	[2]
(iv)	cycle drawn/sum of ΔH(products) – ΔH(products) ✓ –75 – 242 + x = –110 ✓ ΔH = (+)207 kJ mol^{-1} ✓	[3]
(c)	production of margarine/ammonia/Haber process ✓	[1]

Question Number	Answer	Max Mark
5(a)	when the conditions on a system in equilibrium are changed ✓ the equilibrium moves to minimise the effects of the change/ counteract/ resist/ oppose the change ✓	[2]
(b)(i)	equilibrium moves towards LHS/ towards NO_2 ✓ forward reaction is exothermic/ reverse reaction is endothermic ✓	[2]
(ii)	equilibrium moves towards RHS/ towards N_2O_4 (1) fewer moles on RHS (1)✓	[2]
(iii)	no change in equilibrium position ✓ catalyst speeds up forward ad reverse reactions by same amount ✓	[2]
(c)(i)	curve displaced to the right ✓ maximum is lower ✓	[2]
(ii)	area under curve exceeding E_a = number of molecules that can react ✓ at higher temperature, area under curve > E_a is greater so more can react ✓	[2]
6(a)	O_2 ClO ✓ (both needed) $O_3 + O \rightarrow 2O_2$ ✓	[2]
(b)(i)	$C_7H_{16} + 11\frac{1}{2} O_2 \longrightarrow 7CO_2 + 8H_2O$ products ✓ balance ✓	[2]
(ii)	absorb IR ✓ C=O bonds vibrate. ✓	[2]
(c)(i)	M_r C_7H_{16} = 100 ✓ amount = 2000/100 = 20 mol ✓	[2]
(ii)	energy saved = 20 x 4817 = 9634 kJ ✓	[1]
(iii)	moles CO_2 = 7 x 20 = 140 mol ✓ decrease in CO_2 = 140 x 24 = 3360 dm^3 ✓	[2]

Question Number	Answer	Max Mark
(d)	mole ratio = 88.89/12 : 11.1/1 = 7.41 : 11.1 ✓ empirical formula = C_2H_3 ✓ relative mass of C_2H_3 = 27. M_r = 2 x 29 so molecular formula = C_4H_6 ✓ **X** reacts with 2 mol H_2 so there are 2 double bonds ✓ Possible structure = 1,3-butadiene /  ✓	[5]
7(a)	structural isomerism: structural isomers: same molecular formula, different structural formula ✓ structural isomers of but-1-ene: but-2-ene ✓ and methylpropene ✓ geometric isomerism C=C prevents rotation of the double bond✓ each C in the C=C double bond bonded to 2 different atoms or groups ✓ a clear statement that links non-rotation of the double bond to the idea of groups being trapped on one side of the double bond✓ *cis* but-2-ene clearly identified ✓ *trans* but-2-ene clearly identified ✓	[7]
7 (b) 1st bullet	product: $CH_3CH_2CHBrCH_2Br$ ✓ equation: $CH_3CH_2CH{=}CH_2 + Br_2 \longrightarrow CH_3CH_2CHBrCH_2Br$ ✓ products: $CH_3CH_2CHBrCH_3$ **and** $CH_3CH_2CH_2CH_2Br$ ✓ (or statement that 2-bromo- is formed) equation: $CH_3CH{=}CHCH_3 + HBr \longrightarrow CH_3CH_2CHBrCH_3$ ✓ (*i.e*. for one product) products: $CH_3CH_2CHOHCH_3$ **and** $CH_3CH_2CH_2CH_2OH$ ✓ (or statement that 2-ol is formed) equation: $CH_3CH{=}CHCH_3 + H_2O \longrightarrow CH_3CH_2CHOHCH_3$ ✓ (*i.e.* for one product)	[6]

Question Number	Answer	Max Mark
7 (b) 2nd bullet	 1 mark for skeleton with two repeat units ✓ 1 mark for correct groups on side chains ✓	[2]
7 (b) 3rd bullet	two ✓✓ from energy from incineration development of biodegradable polymers cracking of waste polymers	[2]
	Paper Total	[100]