A Level AQA Chemistry

Chapter 24 – answers

Question	Answers	Extra information	Mark	AO Spec reference
01.1	A base is a proton acceptor Amines have a lone-pair of electrons on the nitrogen that can accept a proton	Accept H^+ for proton	1 1	AO1 3.3.11.2 3.1.12.1
01.2	On compound A, the lone pair electrons on the nitrogen can be delocalised onto the ring Reducing the availability of the lone-pair electrons (on the nitrogen) making it harder to accept a proton On compound B, the methyl groups push electrons towards the nitrogen Increasing the availability of the lone-pair electrons (on the nitrogen) making it easier to accept a proton	Accept reducing the electron density on the nitrogen Accept increasing the electron density on the nitrogen	1 1 1 1	AO1 3.1.12.1
01.3	A – 15s B – 40s The more basic B will be retained for longer on the weakly-acidic stationary phase	Need both times for mark	1 1	AO1 AO2 3.3.11.2 3.3.16
01.4	Total area of peaks = A(½ × 10 × 8) + B(½ × 10 × 3) + = 55 A – 72.7% B – 27.3%	Give 2 marks if these answers are given	1 1	AO3 3.3.16
02.1	<table><tr><th></th><th>Carbon</th><th>Hydrogen</th><th>Oxygen</th></tr><tr><td>No. of moles</td><td>58.88/12 = 4.91</td><td>9.80/1 = 9.80</td><td>31.37/16 = 1.96</td></tr><tr><td>Relative number of atoms</td><td>4.91/1.96 = 2.50 5</td><td>9.80/1.96 = 5 10</td><td>1.96/1.96 = 1 2</td></tr></table> The empirical formula = $C_5H_{10}O_2$. From molecular ion peak; M_r = 102 = empirical formula mass Therefore, molecular formula = $C_5H_{10}O_2$	This is such a well-practised type of question that 1 mark only is awarded for this part.	1 1	AO1 3.1.2.4 3.3.6.2

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02.2	The 3 possible compounds are: $CH_3COOCH_2CH_2CH_3$ $CH_3CH_2COOCH_2CH_3$ $CH_3CH_2CH_2COOCH_3$		1	AO2 3.3.9.1
02.3	There are no marks for matching the letter to the correct choice. Chemically different ≡ different environments C is $CH_3CH_2CH_2COOCH_3$ Singlet at δ = 3.65 ppm is for the $OC\mathbf{H}_3$ protons with zero chemically different protons on an adjacent carbon. The sextet at δ = 2.23 ppm is due the $COCH_2C\mathbf{H}_2CH_3$ because there are 5 chemically different protons on adjacent 2 carbons producing spin-spin coupling. The triplet at δ = 1.63 ppm is due to the $CO\text{-}C\mathbf{H}_2\text{-}$ protons because of the 2 chemically different protons on the adjacent $\text{-}CH_2\text{-}$ group. D is $CH_3CH_2COOCH_2CH_3$ The quadruplet at δ = 4.15 ppm is due the $OC\mathbf{H}_2\text{-}$ protons being split by the 3 adjacent, chemically different protons on the $\text{-}CH_3$ group. The quadruplet at δ = 2.25 ppm is due the $COC\mathbf{H}_2\text{-}$ protons being split by the 3 adjacent, chemically different protons on the $\text{-}CH_3$ group E is $CH_3COOCH_2CH_2CH_3$ The singlet at δ = 2.05 ppm is due to the $COC\mathbf{H}_3$ protons with zero chemically different protons on an adjacent carbon.		 1 1 1 1 1 1	AO3 3.3.15

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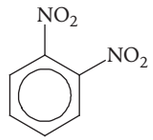
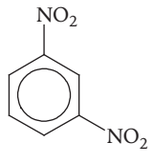
	The sextet at δ = 1.85 ppm is due to the $OCH_2C\mathbf{H_2}CH_3$ protons and the splitting is caused by spin-spin coupling with **5** (n+1 rule) chemically different protons on adjacent carbons. The triplet at δ = 4.15 ppm is due to the $OC\mathbf{H_2}$- protons with the 2 CH_2 protons on the adjacent carbon causing the splitting.	If do not get full marks, then award 1 mark if mention n+1 rule and spin-spin coupling in the correct context.	1 1	
03.1	The 2-chloromethylbenzene has carbons in 7 different environments and therefore will give 7 peaks in the ^{13}C-NMR spectrum. The 4-chloromethylbenzene has carbons in 5 different environments and therefore will give 5 peaks in the ^{13}C-NMR spectrum.		1 1	AO2 3.3.15
03.2	Sulfuric acid - catalyst Nitric acid supplies/is source of nitronium ions	Allow nitrating reagent	1 1	AO1 3.3.10.2
03.3	$C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$		1	AO1 3.3.10.2
03.4	 1,2-dinitrobenzene  1,3-dinitrobenzene  1,4-dinitrobenzene	Names not required for mark although they may be used in answer to parts **03.2** and **03.3**	1+1+1	AO1 3.3.10.2; 3.3.1.1;
03.5	Each isomer has carbon atoms in different numbers of (chemical) environments The number of peaks on the ^{13}C-NMR spectrum will give the identity of the isomer 1,2 dinitrobenzene gives 3 peaks; 1,3 dinitrobenzene would give 4 peaks and 1,4 dinitrobenzene gives 2 peaks	Allow different numbers of chemically different carbons	1 1 1	AO2 3.3.15

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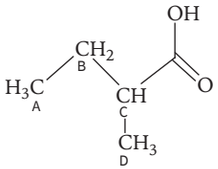
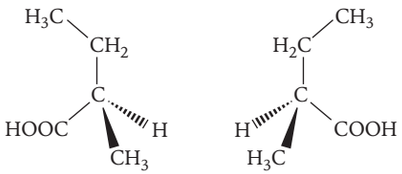
Question	Answers	Extra information	Mark	AO Spec reference
04.1	F is 2-methylbutan-1-ol It is a primary alcohol because its infrared spectrum shows a peak at 3200-3600 cm^{-1} And it can be oxidised to a carboxylic acid because the product of oxidation, has a peak at 1700 cm^{-1} for the C═O group and a broad peak at 2500-3300 cm^{-1} – the -OH group of a carboxylic acid. 2-methylbutan-1-ol has a chiral carbon and therefore can exhibit optical isomerism.	Allow contains $-CH_2OH$ group	1 1 1	AO3 3.3.7; 3.3.5.2; 3.3.6.3
04.2	 There will be 4 sets of peaks because there are 4 different environments for protons The peak for the 3 protons on carbon A will be a triplet because of the spin-spin coupling with the 2 chemically different protons on carbon B The peak for the 2 protons on B will be a pentuplet (quintet) because of the spin-spin coupling with the 3 chemically different protons on carbon A and the single proton on carbon C. Some reference to the n+1 rule and spin-spin coupling anywhere in the right context The single proton has a total of 5 chemically different protons (2 on B and 3 on D) so its peak will be split into a sextuplet The peak for the 3 protons on carbon D will be split into a doublet because of spin-spin coupling with the single proton on carbon C		1 1 1 1 1 1 1	AO3 3.3.15
04.3		1 mark for mirror images and 1 for 3-dimensional representation Allow C_2H_5- for $-CH_2CH_3$	2	

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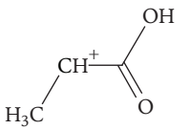
Question	Answers	Extra information	Mark	AO Spec reference
05.1	2-amino-4-methylpentanoic acid		1	AO1 3.3.1.1; 3.3.13.1
05.2	There are 5 different chemical environments for the carbons in leucine so there will be 5 peaks in its ^{13}C-NMR spectrum AND There are 6 different chemical environments for the carbons in isoleucine so there will be 6 peaks in its ^{13}C-NMR spectrum		1	AO2 3.3.15
05.3	i) I This refers to the proton on carbon-2 of the chain (next to COOH group) There are 2 chemically different protons on the adjacent carbon. So applying the n+1 rule it will split into a triplet. The integration shows that it is just 1 proton II There are 6 protons responsible for the peak These protons are the 2CH (methyl) groups They are split into a doublet spin-spin coupling with the CH proton on the adjacent carbon		1 1 1 1 1 1	AO3 3.3.15
05.3	ii) The proton responsible for this is the CH proton on carbon 2 of the chain It has 1 proton on the adjacent carbon atom and therefore is split into a doublet		1 1	AO3 3.3.15
05.4	They have very similar chemical structures Therefore, they will interact equally strongly with the stationary phase of the column or tlc plate and move with similar rate/speed		1 1	AO2 3.3.15
06.1	The structure of the electrophile is:  $CH_3CHClCOOH + AlCl_3 \rightarrow AlCl_4^- + CH_3CH^+COOH$	Allow CH_3CH^+COOH Allow $AlCl_4^-CH_3CH^+COOH$	1 1	AO3 3.3.10.2

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06.2	δ = 4.0 ppm: Proton on C4 Peak is due to 1 proton Quadruplet due to spin-spin coupling with 3 protons on adjacent C5 δ = 2.45 ppm: 2 protons on C3 Doublet due to spin-spin coupling with 1 proton on adjacent C2		 1 1 1 1 1 1	AO3 3.3.15 AO3 3.3.15
06.3	Use ^{13}C-NMR Ibuprofen has 10 carbons in different environments and the impurity has 12 carbons in different environments		1 1	AO2 3.3.15

Skills box answers:

1. Hands (for example grease from the skin) could contaminate the TLC plate. (Reject 'safety concerns'.)
2. To ensure the drops are (very) small / a dropping pipette would release drops that are too big.
3. To saturate the atmosphere in the development chamber; to prevent the release of toxic solvent vapour.
4. A UV lamp can show up compounds that are colourless/not visible, or that the ninhydrin spray does not show.
5. A greater number of substances will be able to dissolve in it, or to alter the speed at which the solvent front moves up the plate.

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