# A Level OCR Chemistry

## Chapter 26 – answers

<table>
<tr><th>Question</th><th>Answers</th><th>Extra information</th><th>Mark</th><th>AO<br>Spec reference</th></tr>
<tr><td>1(a)</td><td>A – hydrogen bonding<br>B – permanent dipole- dipole forces</td><td><br>Allow van der Waal's forces</td><td>1<br>1</td><td>AO2<br>2.2.2k</td></tr>
<tr><td>1(b)(i)</td><td>Add bromine water to solution of phenol</td><td>Allow: add neutral iron(III) chloride solution</td><td>1</td><td>AO1<br>6.1.1i</td></tr>
<tr><td>1(b)(ii)</td><td>Bromine decolorised and white precipitate formed</td><td>White precipitate is essential/ neutral iron(III) chloride gives purple coloration</td><td>1</td><td>AO1<br>6.1.1i</td></tr>
<tr><td>1(b)(iii)</td><td>$C_6H_5OH(aq) + 3Br_2(aq) \rightarrow C_6H_2Br_3OH(s) + 3HBr(aq)$</td><td>No mark for iron(III) chloride equation</td><td>1</td><td>AO1<br>6.1.1i</td></tr>
<tr><td>1(c)</td><td>A – 40s<br>B – 15s<br>The more polar A will be retained for longer on the polar stationary phase</td><td>Need both times for mark</td><td>1<br><br>1</td><td>AO1<br>6.3.1b<br>AO2<br>6.3.1b</td></tr>
<tr><td>1(d)</td><td>Total area of peaks = A( ½ × 10 × 3) + B ( ½ × 10 × 8)<br>= 55<br>A – 27.3% B – 72.7%</td><td><br><br>Give 2 marks if these answers are given</td><td>1<br><br>1</td><td>AO3<br>6.3.1b</td></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th></th><th>Carbon</th><th>Hydrogen</th><th>Oxygen</th></tr>
<tr><td>Number 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<br>5</td><td>9.80 / 1.96 = 5<br>10</td><td>1.96 / 1.96 = 1<br>2</td></tr>
</table>
The empirical formula = $C_5H_{10}O_2$<br>From molecular ion peak; $M_r$ = 102 = empirical formula mass<br>Therefore, molecular formula = $C_5H_{10}O_2$</td><td></td><td><br><br><br><br>1<br><br>1</td><td>AO1<br>2.1.3c;<br><br><br>4.2.4f;</td></tr>
</table>

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|---|---|---|---|---|
| **2(b)** | The 3 possible compounds are:<br>$CH_3COOCH_2CH_2CH_3$<br>$CH_3CH_2COOCH_2CH_3$<br>$CH_3CH_2CH_2COOCH_3$<br><br>There are a maximum 3 marks for each ester.<br>Chemically different ≡ different environments<br><br>C is $CH_3CH_2CH_2COOCH_3$<br><br>Reasons:<br>• Singlet at δ = 3.65 ppm is for the $OC\mathbf{H}_3$ protons with zero chemically different protons on an adjacent carbon.<br>• The sextet at δ = 2.23 ppm is due the $COCH_2C\mathbf{H}_2CH_3$ because there are five chemically different protons on adjacent two carbons producing spin-spin coupling.<br>• The triplet at δ = 1.63 ppm is due to the $CO\text{-}C\mathbf{H}_2\text{-}$ protons because of the two chemically different protons on the adjacent $\text{-}CH_2\text{-}$ group.<br><br>D is $CH_3CH_2COOCH_2CH_3$<br><br>Reasons:<br>• There are no singlets on the spectrum<br>• The quadruplet at δ =4.15 ppm is due the $OC\mathbf{H}_2\text{-}$ protons being split by the three adjacent, chemically different protons on the $\text{-}CH_3$ group.<br>• The quadruplet at δ = 2.25 ppm is due the $COC\mathbf{H}_2\text{-}$ protons being split by the three adjacent, chemically different protons on the $\text{-}CH_3$ group<br>• Reference to either of the triplets at δ = 0.95 ppm or δ = 1.05 ppm due to splitting by two chemically different protons on adjacent $\text{-}CH_2\text{-}$ group. | The splitting patterns must be identified<br>Allow sextuplet<br><br>Do not award mark for the triplet at δ = 0.93ppm because it does not help in identification of the molecule.<br>Maximum of 3 marks awarded for D<br>This is awarded because the other 2 choices do have singlets<br><br>Allow quartet | 3 × 3 | AO3<br>6.1.3c<br><br>AO3<br>6.3.2b |

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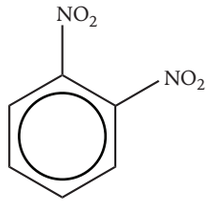
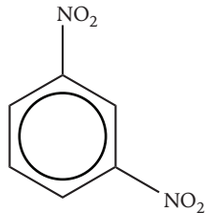
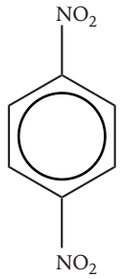
| | E is $CH_3COOCH_2CH_2CH_3$<br><br>Reasons:<br>• The singlet at δ = 2.05 is due to the $COCH_3$ protons with zero chemically different protons on an adjacent carbon.<br>• The sextet at δ = 1.85 ppm is due to the $OCH_2CH_2CH_3$ protons and the splitting is caused by spin-spin coupling with five ($n$+1 rule) chemically different protons on adjacent carbons.<br>• The triplet at δ = 4.15 ppm is due to the $OCH_2$- protons with the two $CH_2$ 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. | | |
| **3(a)** | The 2-chloromethylbenzene has carbons in seven different environments / will give seven peaks in the $^{13}C$-NMR spectrum.<br>The 4-chloromethylbenzene has carbons in five different environments / will give five peaks in the $^{13}C$-NMR spectrum. | | 1<br><br>1 | AO2<br>6.3.2a |
| **3(b)(i)** | Sulfuric acid - catalyst<br>Nitric acid supplies / is a source of nitronium ions | Allow nitrating reagent | 1<br>1 | AO1<br>6.1.1d |
| **3(b)(ii)** | $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$ | | 1 | AO1<br>6.1.1d |
| **3(c)(i)** |  <br>1,2-dinitrobenzene<br>  <br>1,3-dinitrobenzene<br>  <br>1,4-dinitrobenzene | Names not required for mark | 1+1+1 | AO1<br>6.1.1k |

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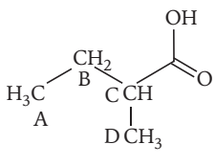
| **3(c)(ii)** | 1,2-dinitrobenzene will give three peaks<br>1,3-dinitrobenzene will give four peaks<br>1,4-dinitrobenzene will give two peaks | | 1<br>1<br>1 | AO2<br>6.3.2a |
| **3(c)(iii)** | 1, 3-dinitrobenzene<br>The nitro (-$NO_2$) group is 3-directing | Allow meta-directing | 1<br>1 | AO2<br>6.3.2a |
| **4(a)** | F is 2-methylbutan-1-ol<br>It is a alcohol because its infrared spectrum shows a peak at 3200-3600 $cm^{-1}$<br>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.<br>2-methylbutan-1-ol has a chiral carbon and therefore can exhibit optical isomerism. | Allow contains -$CH_2OH$ group | <br>1<br>1<br><br><br>1 | AO3<br>4.1.3c;<br>4.2.1c;<br>6.2.2c and d;<br>6.3.2b-e; |
| **4(b)** | Correct structure of 2-methylbutanoic acid<br>  <br><br>There will be four sets of peaks because there are four different environments for protons<br><br>One doublet from three hydrogen atoms on methyl group attached to carbon 2<br>One sextet from one hydrogen atom on carbon 2<br>One pentuplet/quintet/ from two hydrogen atoms on carbon 3<br>One triplet from three hydrogen atoms on carbon 4<br><br>Correct explanation or reference at least once to $n$+1 rule | | 1<br><br><br><br><br>1<br><br>1<br>1<br>1<br>1<br><br>1 | AO3<br>4.2.1c; 4.1.3c;<br>6.3.2e (iii and iv) |

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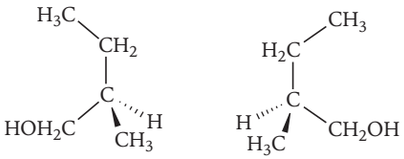
| **4(c)** |  | **1** mark for mirror images<br>**1** for 3D representation<br><br>Allow $C_2H_5$- for -$CH_2CH_3$ | 2 | AO2<br>6.2.2c |
| **5(a)** | 2-amino-4-methylpentanoic acid | | 1 | AO1<br>4.1.1a |
| **5(b)** | Leucine: five peaks<br>Isoleucine: six peaks | Do not allow – they will give different numbers of peaks. | 1 | AO2<br>6.3.2a; |
| **5(c)(i)** | I This refers to the proton on carbon-2 of the chain (next to COOH group)<br>There are two chemically different protons on the adjacent carbon.<br>So applying the $n$+1 rule it will split into a triplet.<br>The integration shows that it is just one proton<br>II There are six protons responsible for the peak<br>These protons are the two-$CH_3$ (methyl) groups<br>They are split into a doublet spin-spin coupling with the CH proton on the adjacent carbon | | 1<br>1<br>1<br><br>1<br>1<br>1 | AO3<br>6.3.2b |
| **5(c)(ii)** | The proton responsible for this is the CH proton on carbon 2 of the chain<br>It has one proton on the adjacent carbon atom and therefore is split into a doublet | | 1<br>1 | AO3<br>6.3.2b |
| **5(c)(d)** | They have very similar chemical structures<br>Therefore they will interact equally strongly with the stationary phase of the column or tlc plate and move with similar rate/speed | Allow – they will have very similar retention times | 1<br>1 | AO2<br>6.3.1b |
| **6(a)** | 2-chloropropanoic acid ($CH_3CHClCOOH$)<br>and aluminium chloride (halogen carrier) | <br>Do not accept just halogen carrier | 1<br>1 | AO2<br>6.1.1d |
| **6(b)(i)** | Proton on C4<br>Peak is due to one proton<br>Quadruplet due to spin-spin coupling with 3 protons on adjacent C5 | | 1<br>1<br>1 | AO3<br>6.3.2d |

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|---|---|---|---|---|
| **6(b)(ii)** | 2 protons<br>on C3<br>Doublet due to spin-spin coupling with one proton on adjacent C2 | | 1<br>1<br>1 | AO3<br>6.3.2d |
| **6(b)(c)** | Ibuprofen has ten carbons in different environments<br>The impurity has twelve carbons in different environments | | 1<br>1 | AO2<br>6.3.2c |

Skills box answers:

**1** **a)** 2.18 (to 3 s.f.)

**b)** 4.45

**c)** 4.13

**d)** −32.0

**e)** 1.30

**f)** 0.477

**g)** 1.78

**2** **a)** $-w = \log_{10} 3.2\times10^{-13} = -12.5 \therefore w = 12.5$

**b)** $e^x = \frac{1250}{50} = 25 \therefore x = \ln(25) \Rightarrow \therefore x = 3.22$

**c)** $y - 3 = \log_{10} 316 = 2.50 y = 3 + 2.5 = 5.5$

**d)** $7.50e^{-\frac{1000}{z}} = 1.37\times10^{-1}$

$e^{-\frac{1000}{z}} = \frac{1.37\times10^{-1}}{7.5} = 0.018266\ldots.$

$-\frac{1000}{z} = \ln 0.018266.. = -4.003$

$\therefore z = -\frac{1000}{4.003} = 250$