2.8 Analytical Techniques: 10-minute Pack

AQA 7405 · Calculator allowed · about 10 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A laboratory technician needs to distinguish three colourless liquids recovered after a synthesis: propan-1-amine ($CH_3CH_2CH_2NH_2$), propanenitrile (CH_3CH_2CN) and propan-1-ol ($CH_3CH_2CH_2OH$), all with similar boiling points. Each is analysed by infrared spectroscopy. Typical absorption ranges: N-H (primary amine) 3300-3500 cm-1 (two bands, medium); C-N triple bond (nitrile) 2200-2260 cm-1 (sharp, medium to weak); O-H (alcohol) 3230-3550 cm-1 (broad, strong); C-H 2850-3100 cm-1.

(a) Identify which functional group gives an absorption in the 2200-2260 cm-1 region, and explain why this absorption is medium to weak in intensity compared with a typical C=O absorption. **(2)**

(b) Explain how infrared spectroscopy alone could distinguish propan-1-amine from propan-1-ol, given both show absorptions in overlapping regions between 3230 and 3550 cm-1. **(3)**

(c) A fourth unknown sample, Q, shows a single sharp absorption at 2245 cm-1 and no absorption anywhere in the 3230-3550 cm-1 region (other than the normal C-H stretches below 3100 cm-1). Identify the functional group present in Q and explain your reasoning, including why no N-H or O-H bands are seen. **(3)**

(Total for Question 1 is 8 marks)

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Mark scheme · 2.8 Analytical Techniques: 10-minute Pack

Question 1

(a) the carbon-nitrogen triple bond in a nitrile group (C-N triple bond) **B1**

(a) the nitrile bond stretch produces a smaller change in dipole moment than a C=O stretch, so it absorbs infrared radiation less strongly, giving a weaker absorption oe **B1**

(a) Answer: The nitrile C-N triple bond; it gives a weaker absorption because its stretch causes a smaller change in dipole moment than a C=O stretch.

(b) propan-1-amine shows two distinct N-H bands (from symmetric and asymmetric N-H stretching), rather than one broad band **B1**

(b) propan-1-ol shows a single, broad, strong O-H absorption across its range, generally broader than the sharper amine N-H bands **B1**

(b) comparing the number and shape (broad versus two sharper bands) of the absorptions in this region allows the two compounds to be distinguished, despite the overlapping wavenumber ranges **B1**

(b) Answer: Propan-1-amine gives two sharper N-H bands; propan-1-ol gives one broad O-H band. Comparing band number and shape distinguishes them.

(c) a nitrile group (C-N triple bond) is present, shown by the sharp absorption at 2245 cm-1, within the nitrile range **B1**

(c) the absence of any band in the 3230-3550 cm-1 region confirms there is no N-H or O-H bond present, ruling out an amine or an alcohol **B1**

(c) this is consistent with Q being a nitrile such as propanenitrile, since a nitrile carbon has no attached N-H or O-H bonds to absorb in that region **B1**

(c) Answer: A nitrile group (C-N triple bond); the 2245 cm-1 band confirms it and the absence of any 3230-3550 cm-1 absorption rules out N-H or O-H.

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