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Answers

Practice exam questions

Andrew Parsons

Check your answers to the questions in this issue.

Every cloud has a silver lining: how silver iodide is used in cloud seeding (pp. 2–5)

1 The insolubility of silver iodide (AgI) in water is mainly explained by its high lattice energy or enthalpy. This means that a significant amount of energy is required to overcome the strong ionic bonds within its crystal structure. The energy released from hydrating the ions (Ag^+ and I^-) is not sufficient to overcome the lattice energy.

2 Silver can have oxidation states of +1, +2, and +3, with +1 being the most common. However, silver(II) or silver(III) iodides are not known compounds, and so the oxidation state of silver does not need to be defined in the name.

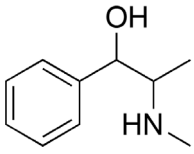
3 The hydrogen bonds in ice are essential for maintaining the hexagonal crystal structure. Each water molecule forms hydrogen bonds with four adjacent molecules, ensuring the structure is open and regular. If hydrogen bonds were absent, the water molecules would not be held in such an open arrangement, and the structure would collapse.

Methamphetamine and chemical profiling (pp. 6–8)

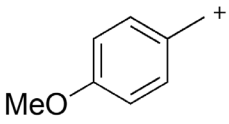
1

2 An oxidising agent such as sodium dichromate ($Na_2Cr_2O_7$) or potassium manganate(VII) (potassium permanganate, $KMnO_4$).

3



4



m/z 121

Titrations: analysing antacids (pp. 13–15)

1 Advantages include:

- titration can provide highly accurate and precise measurements
- the materials and equipment are relatively inexpensive
- it is a versatile technique, since different indicators can be used to analyse a wide range of substances (including acids and bases)
- once mastered, the technique is straightforward to perform.

Disadvantages include:

- the interpretation of the endpoint of the titration is subjective
- it can be time-consuming, especially when titrations need to be repeated
- the burettes need to be well maintained and calibrated
- environmental factors like temperature can affect the accuracy of titration results.

2 1. Add an excess known amount of HCl to gripe water to react fully with $NaHCO_3$.

2. Titrate the remaining unreacted HCl with NaOH (of known concentration).

3. By difference, calculate the number of moles of HCl that reacted with $NaHCO_3$.

4. From this, calculate the number of moles of $NaHCO_3$ present, and use this to determine the mass of $NaHCO_3$ in the gripe water.

3 Total burette uncertainty per titration for 2 readings = 0.07 × 2 = 0.14 cm^3

Percentage uncertainty = (0.14 ÷ 25.0) × 2 = 0.56%

4 Answer: 97.9%

Number of moles of HCl required to neutralise the diluted sample of sodium hydrogen carbonate = (15.3 ÷ 1000) × 0.05 = 7.65×10^{-4} moles.

As the stoichiometry is 1:1, the number of moles of $NaHCO_3$ in this 25 cm^3 portion of diluted gripe water must also be 7.65×10^{-4} moles.

Therefore, the total 100 cm^3 of the diluted gripe water contains:

$4 \times (7.65 \times 10^{-4}) = 3.06 \times 10^{-3}$ moles of $NaHCO_3$.

As this diluted gripe water was prepared from 25 cm^3 of pure gripe water, a 5 cm^3 portion of pure gripe water would only contain:

$(3.06 \times 10^{-3}) \div 5 = 6.12 \times 10^{-4}$ moles of $NaHCO_3$.

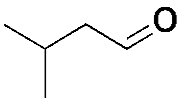
As the molecular mass of $NaHCO_3$ is 84.00 g mol^{-1}, a 5 cm^3 portion of the gripe water would contain (6.12×10^{-4} mol) × 84.00 g mol^{-1} = 0.0514 g.

% purity = (actual mass ÷ stated mass) × 100

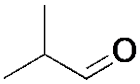
% purity of gripe water = (0.0514 g ÷ 0.0525 g) × 100 = 97.9%

The complex chemistry of the simple spud (pp. 20–25)

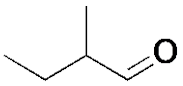
1 **a** 3-methylbutanal



b 2-methylpropanal



c 2-methylbutanal



2 Comparing the number of peaks in the proton-decoupled ^{13}C NMR spectra can be used to distinguish these position isomers. (Proton decoupling eliminates spin-spin coupling, so that the spectra contain a single peak for each carbon environment.)

In 2-methylbutanal, each of the five carbon atoms has a different environment, so the spectrum contains five peaks. In 3-methylbutanal, two terminal methyl groups are equivalent (due to symmetry), so there are just four peaks in the spectrum.

Interpreting ^{1}H NMR spectra (pp. 28–30)

1 Ethyl ethanoate ($CH_3CO_2CH_2CH_3$) and methoxyethane ($CH_3OCH_2CH_3$) both contain an ethyl group (CH_3CH_2–) and a methyl group (–CH_3) group. Consequently, both compounds give three signals in their ^{1}H NMR spectra, which are a singlet, a quartet and a triplet, in the ratio 3:2:3. The key difference is the chemical shift of the CH_3– group. In the ester, the CH_3CO_2– signal is around 2.0 ppm, whereas in the ether, the CH_3O– signal is around 3.2 ppm. The methyl group in the ether has a higher chemical shift value because it is bonded to the electron-withdrawing oxygen.

2 Ethyl ethanoate ($CH_3CO_2CH_2CH_3$) and ethyl methanoate ($HCO_2CH_2CH_3$) both contain an ethyl group (CH_3CH_2–). While ethyl ethanoate has a methyl group bonded to the ester group, ethyl methanoate has a hydrogen atom. Both compounds show a quartet (~4.0 ppm) and a triplet (~1.2 ppm) from the ethyl group. Ethyl ethanoate has a singlet peak around 2.0 ppm for the methyl group (of integration value 3), while ethyl methanoate has a singlet peak around 8.0 ppm for the hydrogen bonded to the ester carbonyl carbon (of integration value 1).

3 $CH_3CH_2COCH_2CH_3$, pentan-3-one. (Both ethyl groups in pentan-3-one are equivalent – it has a plane of symmetry running through the central carbonyl group.)