

Exercise walk-through

5.5.2

Combine analytical evidence and evaluate purification

Pearson Edexcel · International A-Level · Chemistry

Choose a cell voltage

Your turn

Reduction potentials are $+0.80\text{ V}$ and $+0.34\text{ V}$. What is spontaneous E°_{cell} ?

- A. $+1.14\text{ V}$
- B. $+0.46\text{ V}$
- C. -0.46 V

Find oxidation state and coordination

Your turn

$[\text{Cr}(\text{H}_2\text{O})_4\text{Cl}_2]^+$ has which chromium state and coordination number?

- A. +1 and 4
- B. +3 and 6
- C. +3 and 2

Aspirin transfer calculation

Your turn

2.76 g salicylic acid, $M=138$, gives aspirin $M=180$ in 1:1 ratio. Dry mass is 2.52 g. What is yield?

- A. 50.0%
- B. 70.0%
- C. 91.3%

Exercises 2.1·2.3

2.1 A compound contains only carbon, hydrogen and oxygen. Burning 0.740 g gives 1.760 g CO_2 and 0.900 g H_2O . Find empirical formula. Use $\text{C}=12$, $\text{H}=1$, $\text{O}=16$. [5]

2.2 The compound in 2.1 has molar mass 74 g mol^{-1} . Find molecular formula and explain why combustion alone cannot distinguish its structural isomers. [2]

2.3 An unknown $\text{C}_3\text{H}_6\text{O}$ has an aldehyde proton, a $\text{C}=\text{O}$ absorption and positive Tollens' test. Identify it and predict carbon-13 signal count. [2]

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2.1 Carbon moles = $1.760/44 = 0.0400$; carbon mass = 0.480 g. Hydrogen atoms = $2(0.900/18) = 0.100$ mol; mass = 0.100 g. Oxygen mass = $0.740 - 0.480 - 0.100 = 0.160$ g, oxygen = 0.0100 mol. Ratio 4:10:1, C₄H₁₀O.

2.2 The compound in 2.1 has molar mass 74 g mol⁻¹. Find molecular formula and explain why combustion alone cannot distinguish its structural isomers. [2]

2.2 Empirical mass 74, multiplier one, C₄H₁₀O. Different atom connectivities can share that formula.

2.3 An unknown C₃H₆O has an aldehyde proton, a C=O absorption and positive Tollens' test. Identify it and predict carbon-13 signal count. [2]

2.3 Propanal, three distinct carbon environments/signals.

Exercises 3.1·3.3

3.1 A student uses a large volume of hot solvent in recrystallisation, then washes the crystals with much warm solvent. Predict two effects on recovery and explain each. [2]

3.2 Explain when reflux, simple distillation and steam distillation are useful. Include one essential heated-apparatus safety control. [4]

3.3 A solid has a broad melting range below its expected value but a yield above 100%. Evaluate identity and purity, and propose the next preparation step. [3]

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3.1 More product remains dissolved in the larger mother-liquor volume; warm wash dissolves more product than a little cold solvent, both lowering recovery.

3.2 Explain when reflux, simple distillation and steam distillation are useful. Include one essential heated-apparatus safety control. [4]

3.2 Reflux heats without losing volatile reactants. Simple distillation collects a sufficiently separable volatile component. Steam distillation carries a suitable water-insoluble volatile compound at reduced operating temperature. Keep a heated reflux/distillation system open to pressure relief, not sealed.

3.3 A solid has a broad melting range below its expected value but a yield above 100%. Evaluate identity and purity, and propose the next preparation step. [3]

3.3 The data suggest impurity/retained solvent, not proof of pure intended product. Recrystallise as appropriate and dry to constant mass, then remeasure melting range/mass and combine with independent identification evidence.

Exercises 3.4·3.5

3.4 An unfamiliar molecule contains a primary amine and a primary alcohol. Predict its separate reactions with dilute HCl and controlled oxidation with aldehyde distillation. A supplied procedure uses a flammable solvent and a corrosive acid. Give a control for each hazard. [4]

3.5 An unknown ester contains 58.82% C and 9.80% H, the rest O. Its molecular ion is m/z 102. Use C=12, H=1, O=16. It has five carbon-13 environments and proton sets: 3H singlet near 3.7 ppm, 2H triplet near 2.3, 2H multiplet near 1.6, 3H triplet near 0.9. Find the molecular formula and a consistent structure. Explain why ethyl propanoate is rejected and what a fragment at m/z 31 can add to the evidence. [6]

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3.4 The amine accepts H^+ to form an ammonium salt with HCl. Controlled primary-

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3.5 In 100 g, amounts are $\text{C } 58.82/12 = 4.902$, $\text{H } 9.80$, $\text{O } 31.38/16 = 1.961$ mol. Ratio approximately 2.5:5:1, doubled to $\text{C}_5\text{H}_{10}\text{O}_2$; mass 102 matches the molecular ion. Methyl butanoate, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOCH}_3$, fits the five carbon environments and four proton sets. Ethyl propanoate needs an OCH_2 quartet, not an OCH_3 singlet. m/z 31 is consistent with CH_3O^+ and supports the methoxy assignment but is not unique structure proof.