Qualitative Analysis

1(a). This question is about chemicals used by gardeners.

A garden product contains hydrated ammonium iron(II) sulfate, $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$. $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$ contains 27.55% by mass of water of crystallisation.

Calculate the value of x in the formula $(NH_4)_2Fe(SO_4)_2 \cdot xH_2O$.

Show your working.

- (b). The garden product in the previous question part is a solid mixture of the following ingredients:
 - Hydrated ammonium iron(II) sulfate, (NH₄)₂Fe(SO₄)₂•xH₂O, which is soluble in water
 - Crushed limestone (calcium carbonate)
 - Sand.
 - i. Suggest why crushed limestone has been included in this garden product.

	[1]
ii.	 *Plan a procedure on a test tube scale to show that the solid mixture contains the following ions: NH₄⁺, Fe²⁺ and SO₄²⁻ present in (NH₄)₂Fe(SO₄)₂•<i>x</i>H₂O CO₃²⁻ present in crushed limestone. 	
	Show your reasoning, including relevant equations.	

 [6]

2.

A hydrated nickel(II) complex, **A**, is heated in a crucible to remove the water of crystallisation.

The anhydrous complex **B** is formed. The results are shown below.

Mass of crucible + hydrated complex A	= 59.554 g
Mass of crucible + anhydrous complex B	= 58.690 g
Mass of crucible	= 51.257 g

The anhydrous complex **B** is analysed and found to have a molar mass of 309.7 g mol⁻¹ and to contain the following percentage composition by mass:

Ni, 18.95%; C, 23.25%; N, 27.12%; H, 7.75%; C/, 22.93%.

The anhydrous complex **B** contains a cation **C** comprising Ni, C, N and H only. Cation **C** is six-coordinate, contains three molecules of the bidentate ligand **D**, and exists as optical isomers.

Determine the formula of **A**, **B**, **C** and **D** and show the 3D structures for the optical isomers of **C**. Show **all** your working.

[6]
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3. Students work together in groups to identify four different solutions.

Each solution contains one of the following compounds:

- ammonium sulfate, (NH₄)₂SO₄
- sodium sulfate, Na₂SO₄
- sodium chloride, NaCl
- potassium bromide, KBr.

Your group has been provided with universal indicator paper and the following test reagents:

- barium chloride solution
- silver nitrate solution
- dilute ammonia solution
- sodium hydroxide solution.

* A student in your group suggests the following plan:

- Add about 1 cm depth of each solution into separate test-tubes.
- Add a few drops of barium chloride solution to each test-tube.
- A white precipitate will show which solutions contain sulfate ions.
- Two of the solutions will form a white precipitate.

Describe how you would expand this plan so that all four solutions could be identified using a positive test result.

You should provide observations and conclusions that would enable your group to identify all four solutions.

 [6]

END OF QUESTION PAPER