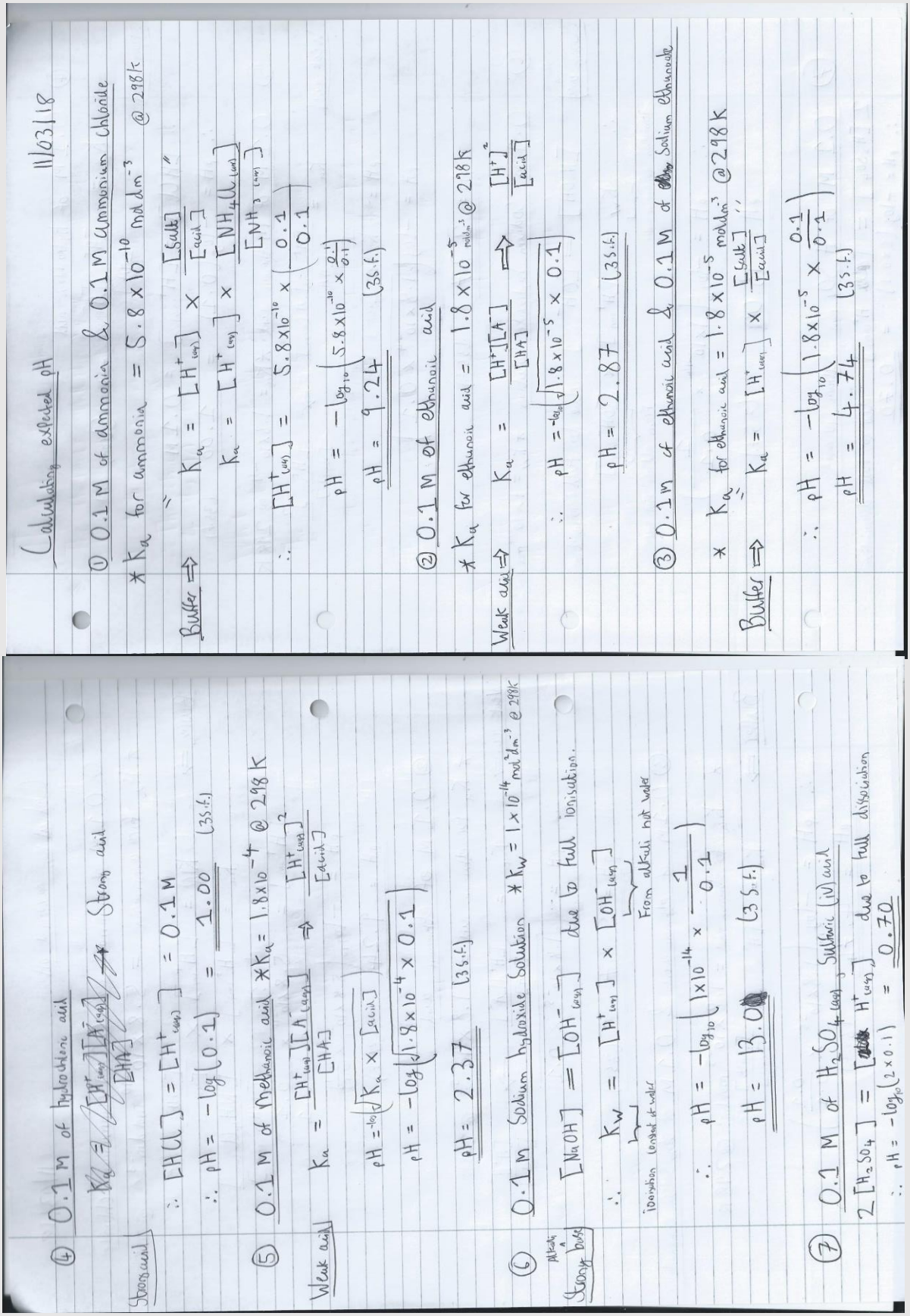
O3.2 ACID, BASES AND BUFFER SOLUTIONS

CALCULATING THE EXPECTED PHS OF THE POSSIBLE SOLUTIONS

This practical aims to identify the solutions used for 7 unknown samples. The following calculations have been made using the Ka values, kW values and assumptions on weak acids, weak bases, strong acids, strong bases and buffer solutions.



An alternative method for calculating the pH of the ammonia + ammonium chloride buffer solution:

① **Alkaline buffer Solution**

The easiest way to calculate pH is to think of the equilibrium in terms of the ion.

e.g. For 0.1M ammonia with 0.1M ammonium chloride

$$NH_{4\,(aq)}^{+} \rightleftharpoons NH_{3\,(aq)} + H^{+}_{(aq)}$$

The Solution contains lots of Unreacted ammonia molecules but also lots of ammonium ions.

The ammonium ions are Weakly acidic and the equilibrium above is set up whenever they are in solution.

A K_a expression can therefore be written for the ammonium ion.

$$K_a = \frac{[NH_3][H^+]}{[NH_4^+]}$$

Assume this is the same as the original ammonia concentration

Assume this is the same as the original ammonium chloride concentration.

$\therefore$ As K_a for the ammonium ion $= 5.62 \times 10^{-10}$ mol dm^{-3} @ 298 K

$$5.62 \times 10^{-10} = \frac{0.1 \times [H^+]}{0.1}$$

$$5.62 \times 10^{-10} = [H^+]$$

$$pH = -\log_{10}(5.62 \times 10^{-10})$$

$$\underline{\underline{pH = 9.25}}$$

ALCULATING THE EXPECTED PHS OF THE POSSIBLE SOLUTIONS

This practical aims to identify the solutions used for 7 unknown samples. The following calculations have been mad using the Ka values

Test tube 1		**Test tube 2**	**Test tube 3**	**Identified solution**
5ml of unknown solution				
Expected pH using pH probe	**Expected colour on addition of phenolphthalein**	**Expected pH after addition of a few drops of 1.0M HCl**	**Expected pH after addition of a few drops of 1.0M NaOH**	
9.25	Light pink	Solution remains at roughly the same pH	Solution remains at roughly the same pH	0.1 mol dm^{-3} ammonia mixed with an equal volume of 0.1 mol dm^{-3} ammonium chloride solution
2.87	Colourless	Solution's pH will decrease	Solution's pH will increase	0.1 moldm^{-3} ethanoic acid
4.74	Colourless	Solution remains at roughly the same pH	Solution remains at roughly the same pH	0.1 mol dm^{-3} ethanoic acid mixed with an equal volume of 0.1 mol dm^{-3} sodium ethanoate solution
1.00	Colourless	Solution's pH will decrease	Solution's pH will increase	0.1 mol dm^{-3} hydrochloric acid
2.37	Colourless	Solution's pH will decrease	Solution's pH will increase	0.1 mol dm^{-3} methanoic acid
13.0	Pink	Solution's pH will decrease	Solution's pH will increase	0.1 mol dm^{-3} sodium hydroxide solution
0.70	Colourless	Solution's pH will decrease	Solution's pH will increase	0.1 mol dm^{-3} sulfuric acid

RESULTS (TABLE 1.0)

Test tube 1		**Test tube 2**	**Test tube 3**	**Unidentified solution**
5ml of unknown solution				
Measured pH using pH probe	**Colour on addition of phenolphthalein**	**pH after addition of a few drops of 1.0M HCl**	**pH after addition of a few drops of 1.0M NaOH**	
				1
				2
				3
				4
				5

				6
				7

METHOD

- 3 X 9ml Glass Test tubes
- Test tube rack
- 3 X dropper pipettes
- Glass rod
- Distilled water
- 25cm^3 of 1.0M HCl acid
- 25cm^3 of 1.0M NaOH
- Phenolphthalein indicator
- 7 X 15ml unknown `buffer and non-buffer' solutions
- pH probe with standard buffer solutions (50cm^3 @ pH 7.0, 50cm^3 @ pH 4.0 and 50cm^3 @ pH 10.0)
- Screw driver to calibrate pH probe
- 3 X 100 ml glass beakers (to hold standard buffer solutions)
- Paper towel (for desiccating apparatus after cleaning with distilled water)

A blank results table (table 1.0) can be used to record the results of the practical.

<u>The pH probe will first require calibrating before it can be used to test solutions.</u>

a. The pH probe's electrode is rinsed well with distilled water at room temperature. The electrode is then swirled around a standard buffer solution of pH 7.0. The value on the meter is adjusted to record 7.0 using a screw driver to turn the fine dial labeled pH 7.0 on the back of the instrument.
b. The pH probe is then rinsed with tap water at room temperature. The electrode is then swirled around a standard buffer solution of pH 10.0. The value on the meter is adjusted to record 10.0 using a screw driver to turn the fine dial labeled pH 4.0 to 10.0 on the back of the instrument.
c. The pH probe is then rinsed with tap water at room temperature. The electrode is then swirled around a standard buffer solution of pH 10.0. The value on the meter is adjusted to record 10.0 using a screw driver to turn the fine dial labeled pH 4.0 to 10.0 on the back of the instrument.
d. The pH probe is then rinsed with tap water at room temperature. The electrode is then swirled around a standard buffer solution of pH 7.0 to ensure that it still records pH 7.0 (+/- 0.1). If it shows a large difference then steps a to d are repeated, else the pH probe has been calibrated successfully.

After calibration of the pH probe, the electrode is rinsed with tap water and a cap can be applied to it to prevent the terminal desiccating when it is not in use.

1. Take an unknown solution and divide equally into 3 separate test tubes (half-filling each test tube). Measure the pH of the solution in test tube 1 using the pH probe, recording the result in the table. Then add a few drops of phenolphthalein indicator and stir with a clean glass rod. Record the observed colour change in the table.
2. Then add a few drops of 1.0M HCl acid to test tube 2 and stir with a clean glass rod. The pH probe must be rinsed with tap water at room temperature. Measure the pH of the solution in test tube 2 using the pH probe. Record if the pH has decreased, increased or stayed roughly the same in the table.
3. Then add a few drops of 1.0M NaOH alkali to test tube 3 and stir with a clean glass rod. The pH probe must be rinsed with tap water at room temperature. Measure the pH of the solution in test tube 3 using the pH probe. Record if the pH has decreased, increased or stayed roughly the same in the table.
4. Repeat steps 1 to 3 for all the unknown solutions. Use a clean glass rod when stirring each solution and rinse the test tubes out with distilled water and dry them with paper towel before moving on to the next unknown solution. The pH probe must be rinsed with tap water at room temperature after use in each new solution (or test tube).

5. Compare the recorded results in table 1.0 with those in the prediction table. This can be used to determine the solution identities.

RISK ASSESSMENT

Hazard	Risk	Precaution	Reference
Broken glass	Can cause cuts and splinters	Handle with care (place in the middle of the desk at all times). Secure all glass so that they do not roll and break. If broken remove immediately using a dustpan and brush.	N/A
0.1 mol dm^{-3} ammonia solution	Low hazard - but may still cause harm to eyes or in a cut	Ensure the lab is well-ventilated. Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (30)
0.1 mol dm^{-3} ammonium chloride solution	Harmful. Warming with alkali will generate ammonia gas. May cause damage to eyes.	Ensure the lab is well-ventilated. Keep solution away from warming. Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (37)
0.1 mol dm^{-3} ethanoic acid	Low hazard - but may still cause harm to the eyes or in a cut. Can irritate the skin.	Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (23)
0.1 mol dm^{-3} sodium ethanoate solution	Can cause serious eye damage/irritation	Wear eye protection at all times. Wear a protective lab coat. Wash hands	https://pubchem.ncbi.nlm.nih.gov/compound/Sodium_ac

		immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	etate#section=Saety-and-Hazards & CLEAPSS – Student Safety Sheet (43)
0.1 mol dm^{-3} hydrochloric acid	Low hazard. Can cause harm to the eyes. Can harm cells in an open wound/cut. Irritating to the skin.	Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (20)
0.1 mol dm^{-3} methanoic acid	Low hazard - but may still cause harm to the eyes or in a cut. Can irritate the skin.	Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (23)
0.1 mol dm^{-3} sodium hydroxide solution	Irritant to the eyes and skin	Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, rinse with plenty of water and mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (31)
1.0M Hydrochloric acid, HCl	Low hazard. Can cause harm to the eyes. Can harm cells in an open wound/cut. Irritating to the skin.	Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Flood eyes with water for 10 minutes if it enters the eye. If spilt, neutralise with sodium hydrogen carbonate solution and rinse with plenty of water. Mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (20)
1.0M Sodium hydroxide, NaOH	Corrosive. Can cause severe burns to the skin. Particularly dangerous to the eyes. Harms the skin/cells	Wear eye protection at all times. Wear a protective lab coat. Wash hands immediately if in contact. Cover any cuts with a	CLEAPSS – Student Safety Sheet (31)

	when it enters a cut. Exothermic reaction on the addition of a strong acid.	plaster before the practical. Flood eyes with water for 10 minutes if it enters the eye. If spilt, neutralise with a citric acid solution and rinse with plenty of water. Mop up with a damp cloth.	
Phenolphthalein indicator	Low hazard. Skin contamination. May cause adverse effects on the body. Usually made with a solvent such as ethanol that is flammable.	Keep away from naked flames. Wash skin immediately if in contact. Do not consume. If spilt mop up with a damp cloth.	CLEAPSS – Student Safety Sheet (70)