Question 37 **(17 marks)**

A student standardised an approximately 0.1 mol L^{-1} sodium hydroxide solution with a standard 0.0958 mol L^{-1} hydrochloric acid solution. The student pipetted 20.00 mL of the sodium hydroxide solution into a conical flask, added 2 drops of indicator and titrated to the end point with the hydrochloric acid. Five titrations were performed.

(a) Below is a table of the student's results. Determine the average titre. (1 mark)

Titration number	Burette readings (mL)		
	Initial	Final	Titre
Rough	1.35	22.45	21.10
1	21.45	41.50	20.05
2	3.50	23.65	20.15
3	23.65	43.05	19.40
4	2.75	22.85	20.10
		Average titre	

(b) Show that the concentration of the sodium hydroxide solution is 0.0963 mol L^{-1}, correct to three significant figures. (3 marks)

The student used the standardised sodium hydroxide solution to determine the percentage by mass of phosphoric acid (H_3PO_4) in a commercial brand of rust remover.

The student weighed a sample of the rust remover into a small beaker and then transferred it to a 250.0 mL volumetric flask. The beaker was rinsed several times with distilled water and each time the wash water was added to the volumetric flask. The volumetric flask was then made up to the mark with more distilled water. The student titrated 10.00 mL aliquots of the diluted rust remover with the standardised sodium hydroxide solution.

The student's results were as follows:

- mass of undiluted rust remover = 10.05 g
- average titre of standardised sodium hydroxide solution = 24.45 mL.

(c) Calculate the percentage, by mass, of phosphoric acid in the original, undiluted rust remover. Express your answer to the appropriate number of significant figures. Assume that the rust remover contains no other substances that react with sodium hydroxide.

(8 marks)

The following table provides some information about three different acid-base indicators.

Indicator	pH range	Acid colour	Base colour
methyl orange	3.2 – 4.4	red	yellow
bromothymol blue	6.0 – 7.6	yellow	blue
phenolphthalein	8.3 – 10.0	colourless	pink

(d) Which of these indicators should the student use when titrating phosphoric acid with sodium hydroxide? Justify your choice with the aid of a relevant balanced chemical equation. (5 marks)