Cambridge Assessment International Education

Cambridge International AS & A Level

Preparing a solution of a primary standard – Topic questions

The questions in this document have been compiled from a number of past papers, as indicated in the table below.

Use these questions to formatively assess your learners' understanding of this topic.

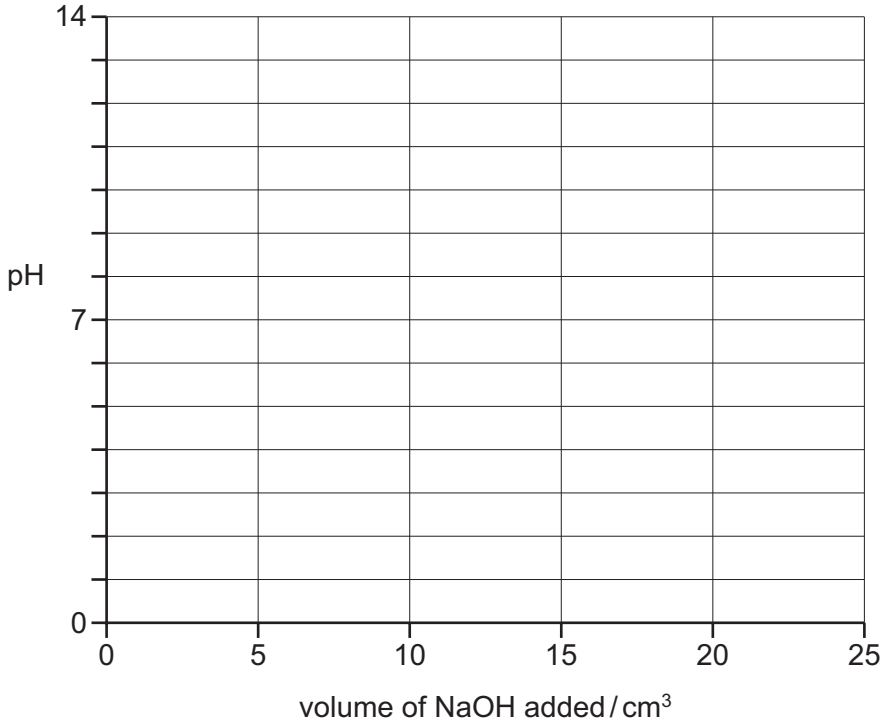
Question	Year	Series	Paper number
6(b)(iii)	2017	June	42
5 (b) & (c)	2018	November	42
4(f)	2018	November	43
1(c)	2017	November	52

The mark scheme for each question is provided at the end of the document.

You can find the complete question papers and the complete mark schemes (with additional notes where available) on the School Support Hub at www.cambridgeinternational.org/support

A 10.0 cm^3 sample of 0.100 mol dm^{-3} aminoethanoic acid (glycine) was titrated with 0.100 mol dm^{-3} NaOH. After 20.0 cm^3 of NaOH, an excess, had been added, the pH was found to be 12.5.

(iii) Using the following axes, sketch a graph showing how the pH changes during this titration.



[3]

[Total: 10]

5 **(b)** Sodium nitrite, $NaNO_2$, is a decomposition product from heating sodium nitrate, $NaNO_3$.

A student analysed a sample of sodium nitrite by titration with aqueous cerium(IV) ions, $Ce^{4+}(aq)$. The equation for the titration reaction is shown.

$$NO_2^-(aq) + 2Ce^{4+}(aq) + H_2O(l) \rightarrow 2Ce^{3+}(aq) + NO_3^-(aq) + 2H^+(aq)$$

- 0.138 g of impure sodium nitrite was dissolved in water and made up to 100 cm^3 in a volumetric flask.
- 25.0 cm^3 of this solution required 21.80 cm^3 of 0.0400 mol dm^{-3} $Ce^{4+}(aq)$ to reach the end-point.

You should assume the impurity does not react with $Ce^{4+}(aq)$.

Calculate the percentage purity of the sample of sodium nitrite.

..... % [3]

(c) Acidified manganate(VII) ions, MnO_4^-, can also be used to analyse solutions containing nitrite ions, NO_2^-, by titration. In acidic solution, NO_2^- ions exist as HNO_2.

(i) Use the *Data Booklet* to construct an ionic equation for this reaction.

.....

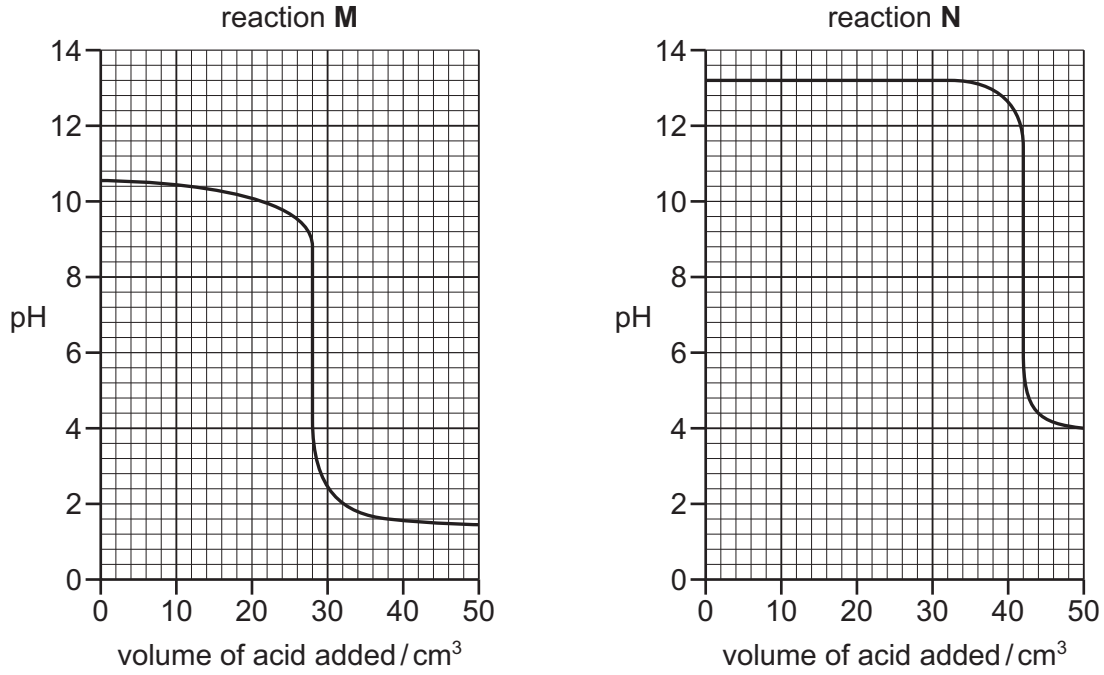
.....

..... [2]

(ii) Use $E^\ominus$ values to calculate the $E^\ominus_{cell}$ for this reaction.

$E^\ominus_{cell}$ = ... V [1]

(f) Titration curves for two different acid-base reactions, **M** and **N**, are shown.



(i) Use the titration curve for reaction **M** to deduce the volume of acid added at the end-point for this titration.

volume of acid added at the end-point = ... cm^3 [1]

(ii) The table shows some acid-base indicators.

name of indicator	pH range of colour change
malachite green	0.2–1.8
bromocresol green	3.8–5.4
bromothymol blue	6.0–7.6
thymolphthalein	9.3–10.6

Name a suitable indicator for each of the acid-base titrations **M** and **N**. Explain your answers.

reaction **M** ..... reaction **N** .....

explanation .....

.....

[2]

(c) Azurite is a blue copper-containing mineral. The copper compound in azurite has the formula $Cu_3(CO_3)_2(OH)_2$. This copper compound reacts with sulfuric acid according to the reaction shown.

$$Cu_3(CO_3)_2(OH)_2(s) + 3H_2SO_4(aq) \rightarrow 3CuSO_4(aq) + 2CO_2(g) + 4H_2O(l)$$

A student performed a series of titrations on 1.50 g samples of solid azurite using 0.400 mol dm^{-3} sulfuric acid.

It can be assumed that any other material present in azurite does not react with sulfuric acid.

The titration data is given in the table.

experiment	rough	1	2
final reading / cm^3	25.50	24.05	32.70
initial reading / cm^3	0.00	0.15	8.30
titre / cm^3	25.50	23.90	24.40

The indicator for the titration was bromophenol blue.

The student concluded that 24.15 cm^3 of 0.400 mol dm^{-3} sulfuric acid completely neutralised 1.50 g of azurite.

(i) Using the student's value of 24.15 cm^3, calculate the percentage by mass of $Cu_3(CO_3)_2(OH)_2$ in the sample of azurite.

Write your answer to **three significant figures**.

[M_r: $Cu_3(CO_3)_2(OH)_2$ = 344.5]

percentage by mass of $Cu_3(CO_3)_2(OH)_2$ in the sample of azurite = ... % [3]

(ii) Identify **two** possible problems with the student's titration **and** suggest improvements to it.

Problem 1 .....

.....

Improvement 1 .....

.....

Problem 2 .....

.....

Improvement 2 .....

.....

[3]

[Total: 18]

Question	Answer	Marks
6(b)(iii)	curve starts at 5.4 and continuous	**1**
	vertical portion (end point) at vol added = 10.0 cm^3	**1**
	finishes at pH = 12.5 **at 20 cm^3** (and does not increase in pH)	**1**

Question	Answer	Marks
5(b)	• moles of Ce^{4+} = 0.0400 × 21.8 / 1000 = 8.72×10^{-4} (moles of Ce^{4+}) • moles of NO_2^- = 8.72×10^{-4} / 2 = 4.36×10^{-4} in 25 cm^3 (use of 2:1 ratio correctly) • moles of NO_2^- = $4.36 \times 10^{-4} \times 4 = 1.74(4) \times 10^{-3}$ in 100 cm^3 (use of 4:1 ratio correctly) • mass $NaNO_2$ = $1.74(4) \times 10^{-3} \times (23.0 + 14.0 + 32.0)$ = 0.120 g (use of M_r correctly) • % purity = 0.120 / 0.138 = 86.96% (use of 0.0138 correctly) two points = [1] four points = [2] all five points = [3]	**3**
5(c)(i)	$5NO_2^- + 2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$ **OR** $5HNO_2 + 2MnO_4^- + H^+ \rightarrow 2Mn^{2+} + 5NO_3^- + 3H_2O$ all species correct [1] balanced [1]	**2**
5(c)(ii)	$E^{\ominus}_{cell}$ = 1.52 – 0.94 = **0.58** (V)	**1**

Question	Answer	Marks
4(f)(i)	end point = 28 cm^3	**1**
4(f)(ii)	**M1** reaction **M** bromothymol (blue) / bromocresol (green) **AND** reaction **N** bromothymol (blue) / thymolphthalein [1] **M2** (both indicators have) a pH range / colour change **within** / **in** end-point / vertical region / sharp fall of the graph [1]	**2**

Question	Answer	Marks
1(c)(i)	moles of $H_2SO_4 = 0.40 \times \frac{24.15}{1000} = 9.66 \times 10^{-3}$ mol	**1**
	mass of $Cu_3(CO_3)_2(OH)_2 = 344.5 \times 9.66 \times 10^{-3} \div 3 = 1.11$ g	**1**
	% by mass = $\frac{1.11}{1.50} \times 100\% = 74.0\%$	**1**

Question	Answer	Marks
1(c)(ii)	Problem 1 titres are not concordant / are too far apart / are 0.5(0) **cm^3** apart / difference is too large Improvement Repeat until (two) concordant titres have been achieved / two readings within 0.1(0) **cm^3** Problem 2 colour change (of indicator) will be masked Improvement 2 Use an alternative indicator / named indicator [1] for each problem, [1] for an improvement	**3**