Titrations - Practice Test ATAR Questions Answers

physics (Sunbury College)

YEAR 12 CHEMISTRY PRACTICE TITRATION CALCULATIONS ANSWERS

ATAR 2021

(a) Other than possessing a relatively high molar mass, state two characteristics required of a substance for it to be used as a primary standard. [2 marks]

Description	Marks
Any two relevant points. Answers could include: • available in very high purity • known purity • very low reactivity with CO_2 and/or O_2 • not deliquescent • not hygroscopic • predictable reactivity • (highly) soluble.	1–2
Total	**2**
Note: • For (highly) soluble, accept '(highly) soluble in water', even though these titrations are not performed in an aqueous medium.	

(b) Complete the following table by writing the name of the most suitable piece of equipment to use for each task. [3 marks]

Task	Piece of equipment to use	Marks
Making exactly 100.0 mL of nicotine-containing solution	volumetric flask	1
Measuring a 20.0 mL aliquot of the nicotine-containing solution	pipette	1
Adding the perchloric acid/acetic acid solution to the nicotine-containing solution	burette	1
	Total	**3**

(c) Use the chemist's titration data to identify the nicotine dosage of the patches in the unlabelled boxes. Show all of your working.

The molecular formula of nicotine is $C_{10}H_{14}N_2$ and the titration reaction is:

$C_{10}H_{14}N_2 + 2\ CH_3COOH_2^+ \rightarrow C_{10}H_{16}N_2^{2+} + 2\ CH_3COOH$ [7 marks]

Description	Marks
n(acid) in 15.11 mL = cV = 0.0483 × 0.01511 = 7.298 x 10^{-4} mol	1
n(nicotine) in 20.0 mL = $\frac{1}{2}$ × 0.000730 = 0.000365 mol	1
n(nicotine) in 100.0 mL = 0.000365 × 5 = 0.00182 mol	1
M(nicotine) = (10 × 12.01) + (14 × 1.008) + (2 × 14.01) = 162.232 g mol^{-1}	1
m(nicotine) in 100.0 mL = 162.232 × 0.00182 = 0.296 g	1
m(nicotine) in 1 patch = 0.296/14 = 0.0211 g	1
thus the boxes contain 21 mg patches	1
Total	**7**

ATAR 2020

(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	

Description	Marks
Average titre = (20.05 + 20.15 + 20.10)/3 = 20.10 mL	1
Total	**1**
Note: • Also accept 20.1 mL as the 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]

Description	Marks
n(HCℓ) = cV = 0.0958 × 0.0201 = 0.00193 mol	1
1 mol NaOH reacts with 1 mol HCℓ	1
c(NaOH) = 0.00193/0.020 = 0.0963 mol L^{-1}	1
Total	**3**

(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]

Description	Marks
$n(NaOH) = 0.0963 \times 0.0245 = 0.00235$ mol	1
Stoichiometry: $3\ NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3\ H_2O$ So, $3\ NaOH : 1 H_3PO_4$	1
$n(H_3PO_4$ reacting in the titration$) = (1 \times 0.00235)/3$ $= 0.000785$ mol in 10 mL	1
$n(H_3PO_4$ in 250 mL volumetric flask$) = (0.000785 \times 250)/10$ $= 0.0196$ mol in 10.05 g	1
$M(H_3PO_4) = 97.994$ g mol^{-1}	1
$m(H_3PO_4$ in rust cleaner sample$) = 0.0196 \times 97.994 = 1.92$ g	1
% H_3PO_4 in the rust cleaner $= (1.92/10.05) \times 100 = 19.1\%$	1
3 significant figures = 19.1%	1
Total	**8**

or

Description	Marks
$n(NaOH) = 0.0963 \times 0.0245 = 0.00235$ mol	1
Stoichiometry: $2\ NaOH + H_3PO_4 \rightarrow Na_2HPO_4 + 2\ H_2O$ So, $2\ NaOH : 1\ H_3PO_4$	1
$n(H_3PO_4$ reacting in the titration$) = (1 \times 0.00235)/2$ $= 0.00118$ mol in 10 mL	1
$n(H_3PO_4$ in 250 mL volumetric flask$) = (0.\ 00118 \times 250)/10$ $= 0.0294$ mol in 10.05 g	1
$M(H_3PO_4) = 97.994$ g mol^{-1}	1
$m(H_3PO_4$ in rust cleaner sample$) = 0.0294 \times 97.994 = 2.88$ g	1
% H_3PO_4 in the rust cleaner $= (2.88/10.05) \times 100 = 28.7\%$	1
3 significant figures = 28.7%	1
Total	**8**
Note: • Phosphoric acid is a weak acid with only two of its three hydrogen atoms reacting with hydroxide to give the 2:1 ratio of $NaOH:H_3PO_4$. This is beyond the scope of the syllabus, and was not expected of students.	

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]

Description	Marks
Phenolphthalein	1
Recognition that PO_4^{3-} present in the solution at equivalence point. ($3\ OH^-(aq) + H_3PO_4(aq) \rightarrow PO_4^{3-}(aq) + 3\ H_2O(\ell)$)	1
The phosphate ion undergoes hydrolysis to form hydroxide ions. $PO_4^{3-} + H_2O \rightleftharpoons HPO_4^{2-} + OH^-$	1
The solution at the equivalence point will be (slightly) basic (with a pH of approximately 9) due to the excess of hydroxide ions ($[OH^-] > [H^+]$)	1
The pH at which the indicator changes colour approximates the pH of the equivalence point.	1
Total	**5**

Note:
- No hydrolysis equation – maximum 4 marks
- Do not accept a statement about strong base is added to weak acid, gives a weakly basic solution as part of the explanation.

Alternative responses that some students may provide

Methyl orange

The pH of the first equivalence point is around 4.7. If students identify this and supply appropriate logic with equations, up to full marks may be awarded.

If a student recognises that the third equivalence point is beyond the end point of phenolphthalein and explains why none of the indicators would be appropriate with sufficient reasoning, up to full marks may be awarded.

(a) Complete the table and determine the average titre. [2 marks]

Description	Marks
Table correctly completed	1
Average titre correctly calculated	1
Example of a two mark response:	

Titration Number	Volume Added (mL)
1	19.47
2	19.44
3	20.34
4	19.39
Average titre	**19.43(3)**

Total	**2**

(b) Identify with what solution each of these pieces of glassware should be rinsed prior to their use in these titrations. [3 marks]

Description		Marks
Glassware item	**Rinse solution**	
5.00 mL pipette	The (concentrated) herbicide	1
20.00 mL pipette	diluted herbicide	1
250.0 mL volumetric flask	Distilled (deionised) water	1
	Total	**3**

(c) Demonstrate whether or not the experimentally determined value of the acetic (ethanoic) acid concentration matches the value given on the herbicide label, bearing in mind that a difference of ± 5.00% is considered acceptable. Show all workings and reasoning. [8 marks]

Description	Marks
Average NaOH titre volume from part (a) = 0.01943 L	
Moles NaOH on average n = cV = 0.0947 x 0.01943 = 0.001840 mol	1
In 20 mL conical flask $n(CH_3COOH) = n(NaOH) = 0.001840$ mol	1
Concentration = 0.001840 / 0.02 = 0.09200 mol L^{-1}	1
In 250 mL volumetric flask, n = 0.09200 x 0.25 = 0.02300 mol	1
All from 5 mL sample… original concentration = 0.02300 / 0.005 = 4.6001 mol L^{-1}	1
$c(CH_3COOH)$ = 4.6001 x 60.052 = 276 g/L	1
The 5% range 295 is 280.25 – 309.75	1
• No • The experimentally determined concentration of acetic acid of 276.3 g L^{-1} falls outside of the error range (280.25 – 309.75 g L^{-1}) stated on the package and so does NOT match the value given on the herbicide label.	1
Total	**8**

Note:
- If the correct answer is clearly stated, full marks maybe awarded for:
  - the correct calculated concentration and error range is calculated
  - and the calculations and reasoning provided clearly demonstrates a correct method for determining the answer.
- If the answer is incorrect or ambiguous, marks may be awarded to the parts correctly completed as set out above.