InkChemistry

ANSWER BOOK

Concentration, volumetric solutions and titration calculations

Amount of substance · Unit C02

AQA 3.1.2.5; RP1 · OCR A 2.1.3; PAG 2

14 questions · 44 marks

NAVY EDITION

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SECTION A · Short, 1 to 2 marks

A1 CVS-Q1

B1 concordant titres agree with each other to within 0.10 cm³. **B1** the mean is calculated from the concordant titres only, leaving out the rough titre and any that do not agree. [2]

A2 CVS-Q11

B1 it shows roughly where the end point lies. **B1** in the accurate runs the solution can be added quickly to just short of that volume and then dropwise, so the end point is not overshot. [2]

A3 CVS-Q12

B1 calcium carbonate is insoluble and reacts slowly, so the end point would be reached before all of it had reacted. **B1** the carbon dioxide given off makes the end point hard to see, whereas an excess of acid reacts with all of it and the leftover acid can be titrated cleanly. [2]

A4 CVS-Q13

B1 sodium hydroxide absorbs water and carbon dioxide from the air while it is being weighed. **B1** the mass weighed is then not all sodium hydroxide, so the concentration calculated from it would be wrong. [2]

SECTION B · Standard, 3 to 5 marks

B1 CVS-Q4

M1 $n(NaOH) = 0.100 \times 0.0250 = 2.50 \times 10^{-3}$ mol. **M1** the ratio $H_2SO_4 : NaOH$ is 1 : 2, so $n(H_2SO_4) = 1.25 \times 10^{-3}$ mol. **M1** $c = 1.25 \times 10^{-3} \div (20.50 \div 1000)$. **A1** $c = 0.0610$ mol dm^{-3}, to three significant figures. [4]

B2 CVS-Q5

M1 $n = 0.100 \times 0.250 = 0.0250$ mol. **M1** $M(Na_2CO_3) = 2 \times 23.0 + 12.0 + 3 \times 16.0 = 106.0$ g mol^{-1}, and $m = 0.0250 \times 106.0$. **A1** $m = 2.65$ g, to three significant figures. **A1** mass concentration $= 0.100 \times 106.0 = 10.6$ g dm^{-3}, or $2.65 \div 0.250$; allow error carried forward from the mass. [4]

B3 CVS-Q8

B1 water left in the burette would dilute the acid, lowering its concentration. **B1** a larger titre would then be needed, so the calculated concentration of the acid would come out too low. **B1** distilled water in the flask adds no carbonate, so the amount delivered by the pipette is unchanged; ignore 'it dilutes the solution'. **B1** rinsing the flask with carbonate solution would leave extra carbonate in it, so the titre would be too large. [4]

B4 CVS-Q3

M1 $n(HCl) = 0.200 \times 21.85 \div 1000 = 4.37 \times 10^{-3}$ mol. **M1** NaOH and HCl react 1 : 1, so $n(NaOH) = 4.37 \times 10^{-3}$ mol, and $c = 4.37 \times 10^{-3} \div 0.0250$. **A1** $c = 0.175$ mol dm^{-3}, to three significant figures. [3]

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B5 CVS-Q7 **M1** the titre is the difference of two readings, so its uncertainty is 2 × 0.05 = ±0.10 cm³. **M1** percentage uncertainty = 0.10 ÷ 18.20 × 100. **A1** 0.55%, to two significant figures. [3]

B6 CVS-Q10 **B1** some solution remains on the beaker, rod and funnel. **B1** rinsing carries all of the weighed solute into the flask, so the concentration matches the mass used. **B1** inverting mixes the solution so the concentration is the same throughout and every portion taken is identical. [3]

B7 CVS-Q18 **M1** mass per dm³ = 0.0250 ÷ 0.500 = 0.0500 mg dm⁻³, and 1 dm³ of dilute solution has a mass of about 1 kg, 10^6 mg. **A1** 0.0500 ppm, to three significant figures. **A1** 0.0500×10^{-3} g dm⁻³ ÷ 207.2 = 2.41×10^{-7} mol dm⁻³, to three significant figures. [3]

B8 CVS-Q19 **B1** it is a solid that can be obtained very pure and is stable in air. **B1** it does not absorb water from the air, so the mass weighed is all sulfamic acid. **B1** it has one acidic hydrogen and reacts with sodium hydroxide in a known 1 : 1 ratio, so the moles weighed give the moles of alkali. [3]

B9 CVS-Q21 **M1** $n(NaOH) = c \times V = 0.100 \times 25.0 \div 1000 = 2.50 \times 10^{-3}$ mol. **M1** the equation gives 2 mol of NaOH for 1 mol of H_2SO_4, so $n(H_2SO_4) = 2.50 \times 10^{-3} \div 2 = 1.25 \times 10^{-3}$ mol. **A1** V = n ÷ c = $1.25 \times 10^{-3} \div 0.100$ = 0.0125 dm³ = 12.50 cm³, every step shown because the answer is given in the question. [3]

SECTION C · Long, 6 marks or more

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C1 CVS-Q15 **Indicative content** [6]

B1 weigh the sodium carbonate by difference, dissolve it in distilled water in a beaker, and transfer it to a volumetric flask with the rinsings of the beaker, rod and funnel. **B1** make up to the line with distilled water, adding the last drops so the bottom of the meniscus is on the line at eye level, then stopper and invert to mix. **B1** rinse a pipette with the carbonate solution and transfer 25.0 cm^3 to a conical flask, using a pipette filler, and add a few drops of methyl orange. **B1** rinse the burette with the acid, fill it, remove the funnel, make sure the tip is full and record the initial reading at eye level. **B1** carry out a rough titration, then accurate titrations adding the acid dropwise near the end point with swirling, until one drop turns the indicator from yellow to orange. **B1** repeat until titres are concordant within 0.10 cm^3 and use their mean, with the 1 : 2 ratio of Na_2CO_3 to HCl, to calculate the concentration of the acid.

Levels

Level 3 (5–6 marks) the standard solution is made with weighing by difference, rinsings transferred and the flask made up to the line, and the titration is carried out with the pipette, burette, indicator, dropwise end point and concordant titres all described, finishing with the 1 : 2 ratio in the calculation.

Level 2 (3–4 marks) the solution is made up in a volumetric flask and the titration done with an indicator and repeats; transferring the rinsings, reading the meniscus, the dropwise approach to the end point, or the concordance criterion is left out.

Level 1 (1–2 marks) sodium carbonate is dissolved and titrated with the acid; the calculation commonly uses a 1 : 1 ratio, and the steps that make the solution standard are missing.

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