Past-paper walk-through

Acids and bases ▪ 25.1

eXercise

Questions in this set

- 9701/42 N25 Q3 ▪ 15 marks
- 9701/51 N25 Q1 ▪ 16 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 3

9701/42 N25 ▪ Q3 ▪ 15 marks

3 (a) (i) Define conjugate acid–base pair.

Question 3

(ii) Give the formulas of the conjugate acid and the conjugate base of the hydrogen phosphate ion, HPO_4^{2-}.

Question 3

Question 3

[1]

(b) The K_a of propanoic acid, CH_3CH_2COOH, is 1.35×10^{-5} mol dm^{-3} at 298 K.

Solution **C** is a solution of CH_3CH_2COOH with a pH of 3.60 at 298 K.

(i) Calculate the concentration of CH_3CH_2COOH in solution **C**.

Question 3

(ii) Calculate the concentration of hydroxide ions in solution **C**.

Question 3

(iii) Calculate the concentration of a solution of hydrochloric acid with the same pH as solution **C**.

Question 3

(iv) Table 3.1 shows three possible values of the K_a of dimethylpropanoic acid, $(CH_3)_3CCOOH$.

Place a tick in Table 3.1 to show the correct value. Explain your answer.

Table 3.1

value of K_a / mol dm^{-3}	place **one** tick (✓) in this column
9.33×10^{-6}	
1.35×10^{-5}	
3.35×10^{-5}	

Question 3

(c) Solution **D** is made by mixing 100 cm^3 of 0.100 mol dm^{-3} CH_3CH_2COOH and 100 cm^3 of 0.100 mol dm^{-3} NaC*l*.

The pH of solution **D** is measured as small amounts of $H_2SO_4(aq)$ are added to it, and when small amounts of NaOH(aq) are added to it.

Solution **D** only acts as a buffer solution when **one** of these solutions is added to it.

(i) Complete the sentence and write an equation for the reaction that occurs.

Question 3

[1]

(ii) Complete the sentence and explain why solution **D** does **not** act as a buffer when the other solution is added.

Question 3

Question 3

Question 3

[1]

(d) Manganese(II) hydroxide, $Mn(OH)_2$, is only slightly soluble in water.

The solubility of $Mn(OH)_2$ in water is $3.28 \times 10^{-3}\,g\,dm^{-3}$ at 298 K.

(i) Calculate the concentration of a saturated solution of $Mn(OH)_2$ at 298 K.

Question 3

(ii) Write an expression for the K_{sp} of $Mn(OH)_2$. Give the units of K_{sp}.

K_{sp} =

Question 3

[2]

(iii) Use your answers to **(d)(i)** and **(d)(ii)** to calculate the value of K_{sp} of $Mn(OH)_2$ at 298 K.

Question 3

[Total: 15]

Solution 3

(a)(i)

Mark scheme

- two species that differ by one proton / H+
- 1

(a)(ii)

Mark scheme

- H2PO4– AND PO43–
- 1

Solution 3

(b)(i)

Mark scheme

- M1: [H+] = 2.51 × 10–4
- M2: [CH3CH2COOH] = 4.67 × 10–3
- 2

Solution 3

(b)(ii)

Mark scheme

- $3.98 \times 10–11$
- 1

(b)(iii)

Mark scheme

HCl $= 2.51 \times 10–4$

- 1

Solution 3

(b)(iv)

Mark scheme

- M1: top box ticked AND weaker acid
- M2: alkyl group is electron donating
- M3: O–H bond strengthened / anion is destabilised
- 3

Solution 3

(c)(i)

Mark scheme

- NaOH AND CH3CH2COOH + OH– → CH3CH2COO– + H2O
- 1

(c)(ii)

Mark scheme

- H2SO4 AND conjugate base of CH3CH2COOH is not present
- 1

Solution 3

(d)(i)

Mark scheme

- $3.69 \times 10–5$
- 1
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Solution 3

(d)(ii)

Mark scheme

- M1: Ksp = [Mn2+][OH–]2
- M2: units = mol3 dm–9
- 2

Solution 3

(d)(iii)

Mark scheme

- 2.0×10–13
- 1

Question 1

9701/51 N25 ▪ Q1 ▪ 16 marks

1 The concentration of aqueous chloride ions can be found by titration with aqueous silver nitrate, $AgNO_3(aq)$.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The indicator used is aqueous potassium chromate(VI), $K_2CrO_4(aq)$.

As $AgNO_3(aq)$ is added to aqueous chloride ions, a white precipitate of $AgCl(s)$ is formed.

When all the chloride ions have reacted, further addition of $AgNO_3(aq)$ leads to the formation of a red precipitate of silver chromate(VI), $Ag_2CrO_4(s)$. The first appearance of the red precipitate shows the end-point of the titration.

A student carries out an experiment to determine the number of molecules of water of crystallisation, x, in hydrated barium chloride, $BaCl_2 \cdot xH_2O(s)$.

(a) The student makes 250.0 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$ to use for the titration.

Question 1

(i) Calculate the mass of solid silver nitrate, $AgNO_3(s)$, needed to make $250.0\,cm^3$ of $0.0500\,mol\,dm^{-3}$ $AgNO_3(aq)$.

Give your answer to **two** decimal places.

Question 1

(ii) Describe how the student should make 250.0 cm^3 of 0.0500 mol dm^{-3} $AgNO_3(aq)$ starting from the mass of $AgNO_3(s)$ calculated in **(a)(i)** in a 50 cm^3 beaker.

Give the name and size of any key apparatus used.

Write your answer using a series of numbered steps.

Question 1

(b) The student uses the following method.

step 1 Dissolve 1.58 g of $BaCl_2 \cdot xH_2O(s)$ to form 250 cm^3 of aqueous solution. Label this solution **A**.

step 2 Transfer 20.0 cm^3 of solution **A** into a conical flask.

step 3 Add aqueous sodium sulfate, $Na_2SO_4(aq)$, to the flask and swirl the mixture to remove barium ions from the solution.

step 4 Add 2–3 drops of $K_2CrO_4(aq)$ indicator to the flask.

step 5 Titrate the contents of the flask against 0.0500 mol dm^{-3} $AgNO_3(aq)$.

step 6 Repeat steps 2 to 5 to collect sufficient data for analysis.

(i) Suggest a suitable piece of apparatus for transferring 20.0 cm^3 of solution **A** in step 2.

Question 1

(ii) Suggest why barium ions are removed in step 3 before performing the titration.

Question 1

(iii) Suggest why chemically resistant gloves should be worn to carry out step 4.

Question 1

(c) The student's results are shown in Table 1.1.

Table 1.1

	rough titration	titration 1	titration 2	titration 3
burette reading (final) / cm^3	20.10	40.55	20.75	20.90
burette reading (initial) / cm^3	0.00	20.25	0.05	0.30
titre / cm^3	20.10	20.30	20.70	20.60

The student uses the titres from titrations 2 and 3 shown in Table 1.1 to calculate a mean titre value of 20.65 cm^3.

(i) Explain why only these two values are used.

Question 1

Question 1

(ii) Calculate the percentage error in the titre volume for titration 3.
Show your working.

Question 1

(d) The equation for the reaction of silver nitrate with barium chloride is shown.

$$2AgNO_3(aq) + BaCl_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2AgCl(s)$$

(i) Calculate the amount, in mol, of $AgNO_3(aq)$ in the mean titre of $20.65\,cm^3$.

Question 1

(ii) Calculate the amount, in mol, of $BaCl_2(aq)$ in $250\,cm^3$ of solution **A**.

Question 1

(iii) Calculate the value of x in the formula $BaCl_2 \cdot xH_2O$.

Question 1

(e) Another student uses a different experimental method to check the value of *x* obtained by the method described in **(b)**.

Give a **brief** description of another method, not involving titration, that could be used to determine the value of *x* in the formula $BaCl_2 \cdot xH_2O(s)$. Write your answer using a series of numbered steps.

Your plan should include details of the following:

- the apparatus and method you would use
- the measurements you would make.

You are provided with standard laboratory apparatus.

Question 1

[Total: 16]

Solution 1

(a)(i)

Mark scheme

- 2.12 g
- 1

Solution 1

(a)(ii) Mark scheme

- M1 add a (small) volume of (distilled) water (to the small beaker)
- AND
- dissolve the solid / AgNO3 (s)
- Transfer the solution and washings (using a funnel)
- AND
- into a 250 cm3 volumetric flask. M3
- Make up to the (calibration) mark / line with distilled water.
- AND

Solution 1

- then invert the (stoppered) flask (several times)
- 3

Solution 1

(b)(i)

Mark scheme

- (20(.0) cm3) pipette.
- 1

(b)(ii)

Mark scheme

- barium (ions) could react with chromate (ions).
- 1

Solution 1

(b)(iii)

Mark scheme

- Potassium chromate(VI) / K2CrO4(aq) is an irritant / corrosive
- 1

Solution 1

(c)(i)

Mark scheme

- They are (the only ones that are) concordant.
- 1

Solution 1

(c)(ii) Mark scheme

- 2
- 0.05 100
- 20.60
- $\times$
- $\times$
- $= 0.48 (54\%)$
- Correct working must be shown.
- 1

Solution 1

(d)(i)

Mark scheme

- $20.65 \times 0.05 \,/\, 1000 = 0.00103(25)$
- 1

Solution 1

(d)(ii)

Mark scheme

- = ((d)(i) / 2) *(250 / 20)
- = (d)(i) $\times$ 6.25
- 1
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Solution 1

(d)(iii)

Mark scheme

- M1 Mr = 1.58 / (d)(ii) M2
- x= (M1 – 208.3) / 18
- AND
- x must be an integer.
- Some working must be shown.
- 2

Solution 1

(e) Mark scheme

- Heat to drive off water of crystallisation. **M1**
- Apparatus
- 1
- Bunsen burner.
- 2
- Crucible (supported by pipeclay triangle) **M2**
- Measurements
- 1

Solution 1

- Measure mass of crucible (+ lid) (empty).
- 2
- Measure mass crucible (+ lid) + solid before heating
- 3
- Measure mass of crucible (+ lid) + residue (after heating.) **M3**
- Key step in method
- ▪
- Description of heat to constant mass.
- OR
- Produce a suitable precipitate using a viable reaction. **M1**

Solution 1

- Apparatus and method
- ▪
- Chooses suitable reagent.
- ▪
- Filter the precipitate.
- ▪
- Wash and (allow to) dry M2
- Measurements
- ▪
- Measure mass of hydrated barium chloride used.

Solution 1

- ▪
- Measure mass of precipitate. M3
- Key step in method
- ▪
- Description of dry to constant mass.
- 3
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