OCR A-Level Chemistry A

Acids, bases and buffers mark scheme · goes with “Acids, bases and buffers” · whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/

Mark schemes

Acids, bases and buffers · 9 questions

Q1 · June 2019 · Paper 1 (Periodic table, elements and physical chemistry) · Q12 · [1 mark]

Answer: **D**

H_3O^+ and H_2O

Q2 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q11 · [1 mark]

Answer: **D**

Colour stays yellow.

Q3 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q12 · [1 mark]

Answer: **C**

NH_4^+ and H_2O

Q4 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q12 · [1 mark]

Answer: **A**

$CH_3COONa(aq)$

Q5 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q19 · [11 marks]

OCR MARK SCHEME EXAMINER GUIDANCE

19(a)(i)

$(K_a) = \dfrac{[H^+]\,[ClCH_2COO^-]}{[ClCH_2COOH]}$ ✓

[1 mark]

DO NOT ALLOW *without square brackets*

DO NOT ALLOW $\dfrac{[H^+]^2}{[ClCH_2COOH]}$

DO NOT ALLOW $\dfrac{[H^+][A^-]}{[HA]}$

19(a)(ii)

$[H^+] = [A^-]$

OR $[H^+]$ from water is negligible

OR dissociation of water is negligible ✓

[1 mark]

Answer must be in terms of concentration

ALLOW $[H^+] \approx [A^-]$

IGNORE $HA \rightleftharpoons H^+ + A^-$ *is a 1:1 mole ratio.*

19(a)(iii)

FIRST CHECK ANSWER ON ANSWER LINE

If answer = 2.85 OR 2.86 OR 2.87 award 3 marks

$([H^+] =)\ 10^{-1.95}$

OR $= 1.1(22...) \times 10^{-2}$ ✓

$(K_a) = \left(\dfrac{[H^+]^2}{[ClCH_2COOH]}\right)$

$= \dfrac{(1.122...\ x10^{-2})^2}{(0.090)}$ **OR** $\dfrac{(1.12\ x10^{-2})^2}{(0.090)}$ **OR** $\dfrac{(1.1\ x10^{-2})^2}{(0.090)}$

$=1.4(0) \times 10^{-3}$ **OR** $=1.39 \times 10^{-3}$ **OR** $= 1.34 \times 10^{-3}$ ✓

$(pK_a = -\log_{10}(K_a) =)$ 2.85, 2.86 OR 2.87 (2DP) ✓

[3 marks]

ALLOW ECF *throughout*

ALLOW $[H^+] = 1.1 \times 10^{-2}$ *up to calculator value*

ALLOW *2 sig figs up to calculator value.*

ALLOW *calculations based on finding the* $[HA]_{equ}$

$\dfrac{(1.122...\ x10^{-2})^2}{(0.079)}$ **OR** $\dfrac{(1.12\ x10^{-2})^2}{(0.079)}$ **OR** $\dfrac{(1.1\ x10^{-2})^2}{(0.079)}$

$=1.59 \times 10^{-3}$ **OR** $=1.59 \times 10^{-3}$ **OR** $= 1.53 \times 10^{-3}$ ✓

$(pK_a = -\log_{10}(K_a) =)$ 2.80 **OR** 2.80 **OR** 2.81 (2DP) ✓

Must be 2DP

Common error:

2 marks

0.90 (not using $[H^+]^2$)

19(b)(i)

Smooth s-shaped curve using a best fit line that goes through the majority of points. ✓

Reading off x-axis at 12.5 cm^3 ✓

$n(Ba(OH)_2) =) \dfrac{0.0560 \times 12.5}{1000}$

DO NOT ALLOW *point to point*

DO NOT ALLOW *tram/feather lines.*

ALLOW *Reading off x-axis from 12.4 – 12.6* cm^3

ALLOW *ECF throughout*

= 7.00×10^{-4} ✓

$n(CH_3COOH =)$ 2 × (moles $Ba(OH)_2$)

= 1.40×10^{-3} ✓

(concentration =) $\dfrac{1.4 \times 10^{-3}}{\left(\dfrac{10}{1000}\right)}$

= 0.14(0) (mol dm^{-3}) ✓

Alternative method based on calculating pK_a from the half neutralisation point.

pH and $[H^+]$ reading will come from the candidates graph and the data points provided.

e.g.

pH at half neutralisation

6.25 cm^3 = pH 4.7 = pK_a ✓

$K_a = 10^{-4.7}$

= 1.995×10^{-5} ✓

$[H^+]$ at pH 3.3 (obtained from data on the graph provided)

$10^{-3.3} = 5.012 \times 10^{-4}$ (mol dm^{-3}) ✓

$[HA] = \dfrac{[H^+]^2}{[K_a]}$

$= \dfrac{(5.012 \times 10^{-4})^2}{(1.995 \times 10^{-5})}$

= 0.0126 (mol dm^{-3}) ✓

[5 marks]

ALLOW *3SF or more unless there is a trailing zero*

Alternative answers:

0.139 (mol dm^{-3}) (from reading off x-axis at 12.4 cm^3)

0.141 (mol dm^{-3}) (from reading off x-axis at 12.6 cm^3)

Common errors:

3 Marks

0.134 (Use of 12 cm^3)

0.202 (use of 18 cm^3)

ALLOW *MP2 for $K_a = 1.7 \times 10^{-5}$ to 1.8×10^{-5} (knowledge of actual K_a value)*

ALLOW *ECF from any quoted K_a*

19(b)(ii)

Phenol red

OR

Phenolphthalein ✓

[1 mark]

Both indicators can change colour on the sharp vertical section of the candidates curve.

Q6 · June 2024 · Paper 3 (Unified chemistry) · Q1 · [10 marks]

OCR MARK SCHEME

1(a)

FIRST, CHECK THE ANSWER ON ANSWER LINE

IF *pH = 13.6(0), award 2 marks*

EXAMINER GUIDANCE

ALLOW ECF *from incorrect $[H^+]$ calculated from $[OH^-]$ AND K_w*

.....for pH > 7 ONLY

$K_w = [H^+] \times 0.400$ **OR** $1.00 \times 10^{-14} = [H^+] \times 0.400$

OR $[H^+] = \frac{K_w}{0.400}$ **OR** $[H^+] = \frac{1.00 \times 10^{-14}}{0.400}$ **OR** $[H^+] = 2.5 \times 10^{-14}$ ✓

$pH = -\log 2.5 \times 10^{-14} = 13.6(0)$ ✓

ALLOW *13.6..... up to calculator value of 13.60205999 correctly rounded*

ALLOW *method based on pOH:*

$pOH = -\log 0.400 = 0.40$ ✓

Calculator: 0.39794...

$pH = 14 - 0.40 = 13.6(0)$ ✓

[2 marks]

1(b)

FIRST, CHECK THE ANSWER ON ANSWER LINE

IF *pH = 1.12, award 1 mark*

$pH = -\log 0.075 = 1.12$ ✓

2 DP required

[1 mark]

1(c)

FIRST, CHECK THE ANSWER ON ANSWER LINE

IF *pH = 4.28, award 2 marks*

$1.75 \times 10^{-5} = \frac{[H^+] \times 0.100}{0.300}$

OR $[H^+] = \frac{1.75 \times 10^{-5} \times 0.300}{0.100}$

OR $[H^+] = 5.25 \times 10^{-5}$ (mol dm^{-3}) ✓

$pH = -\log 5.25 \times 10^{-5} = 4.28$ ✓

2 DP required

[2 marks]

COMMON ERRORS

1 mark for 5.23 inverted [HA] and [A$^-$]

$[H^+] = \frac{1.75 \times 10^{-5} \times 0.100}{0.300}$

OR $5.83.... \times 10^{-6}$ ✗

$pH = -\log 5.83.... \times 10^{-6} = 5.23$ ✓ **ECF**

1 mark for 4.46 [HA] = 0.2 instead of 0.3

$[H^+] = \frac{1.75 \times 10^{-5} \times 0.200}{0.100}$

OR 3.5×10^{-5} ✗

$pH = -\log 3.5 \times 10^{-5} = 4.46$ ✓ **ECF**

Other **ECF** available from ONE transcription error ONLY, e.g.

1.57×10^{-5} for $K_a = 1.75 \times 10^{-5}$

Zero marks for square root approach

e.g. via $K_a = \frac{[H^+]^2}{0.300}$

Zero marks for $[A^-] : [HA] = 0.1 : 0.1$

i.e. $[H^+]$

$= \frac{1.75 \times 10^{-5} \times 0.100}{0.100} = 1.75 \times 10^{-5}$ ✗

pH = 4.76 ✗

ALLOW *Henderson-Hasselbalch for both marks:*

e.g. $pH = 4.76 + \log \frac{0.100}{0.300}$

OR $pH = -\log(1.75 \times 10^{-5}) + \log \frac{0.100}{0.300}$ ✓

OR $pH = -\log(1.75 \times 10^{-5}) - \log \frac{0.300}{0.100}$

pH = 4.28 ✓

ALLOW ECF *throughout*

1(d)

Calculation 2 marks

$n(Cu(NO_3)_2 \cdot 3H_2O) = \frac{0.200 \times 100}{1000}$

ALLOW ECF *from incorrect* $n(Cu(NO_3)_2 \cdot 3H_2O)$

OR $2(.00) \times 10^{-2}$ (mol) **OR** 0.02(00) ✓

Mass $Cu(NO_3)_2 \cdot 3H_2O = 2.00 \times 10^{-2} \times 241.5 = 4.83$ (g) ✓

4.83 g subsumes 1st mark

ALLOW *small amount/some*

2 or more DP to match balances

DO NOT ALLOW *100 cm^3 or more of water*

Method 3 marks

IGNORE *solvent*

Dissolve solid in (distilled) water (less than 100 cm^3) (in beaker) ✓

ALLOW *graduated flask*

Transfer (solution) to volumetric flask

ASSUME that wash/rinse is to a volumetric flask

AND

ALLOW *swirl/shake*

Wash/rinse (from beaker to flask) ✓

Make up to mark/up to 100 cm^3 with (distilled water)

ALLOW *preparation of solutions > 100 cm^3 4 marks*

AND

Invert flask (several times to ensure mixing) ✓

e.g. for 250 cm^3

[5 marks]

$n(Cu(NO_3)_2 \cdot 3H_2O) = \frac{0.200 \times 250}{1000}$

OR 0.05 (mol) ✗

Mass $Cu(NO_3)_2 \cdot 3H_2O = 0.05 \times 241.5 = 12.075$ (g) ✓

Then method adapted for 250 cm^3 volumetric flask

e.g. Make up to 250 cm^3 with water

Q7 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q13 · [1 mark]

Answer: **C**

pH range of the indicator: 9.4 –10.6

Q8 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q19 · [12 marks]

OCR MARK SCHEME

19(a)

0.82 ✓

[1 mark]

EXAMINER GUIDANCE

(pH = –log(0.15)) =0.82

2 DP required

19(b)(i)

Higher (pH) **AND**

(Nitric acid fully ionises and) nitrous acid partially dissociates/ionises ✓

Lower <u>concentration</u> of H^+ ions (in nitrous acid) ✓

[2 marks]

DO NOT ALLOW *nitric acid is a stronger acid (in the question)*

IGNORE *easily dissociates*

IGNORE *does not fully dissociate/dissociates less*

ASSUME "It" refers to HNO_2

19(b)(ii)

(Simultaneous) oxidation and reduction of (the same) <u>element</u> ✓

N from +3 (in HNO_2) to +5 (in HNO_3)

AND

N from +3 (in HNO_2) to +2 (in NO) ✓

N is oxidised to HNO_3

AND

N is reduced to NO ✓

[3 marks]

ALLOW *N / nitrogen for element*

IGNORE *species for element*

+ required

ALLOW *3+, 5+, and 2+*

DO NOT ALLOW N^{3+}, N^{5+} *and* N^{2+}

ALLOW *clearly assigned oxidation numbers above the equation if not quoted on the answer line*

19(c)

Level 3 (5–6 marks)

ALLOW *use of 2 SF up to calculator value*

Correct method for the calculation of $[H^+]$

AND correct method for the calculation of $[CH_3CH_2COO^-]$

AND correct mass of CH_3CH_2COONa **AND** explains how pH changes in a buffer when OH^- is added with reference to an equilibrium equation

There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.

Level 2 (3–4 marks)

Correct method for the calculation of $[H^+]$

AND correct method for the calculation of $[CH_3CH_2COO^-]$

AND

attempt at a method for calculation of mass of CH_3CH_2COONa

OR an attempt at an explanation of how pH changes in a buffer when OH^- is added

OR

Correct method for the calculation $[H^+]$

AND attempt of method for calculating $[CH_3CH_2COO^-]$

AND

correct method for calculation of mass of CH_3CH_2COONa **OR** an attempt at an explanation of how pH changes in a buffer when OH^- is added

There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.

Level 1 (1–2 marks)

Method for the calculation of $[H^+]$

AND

$[CH_3CH_2COO^-]$ **OR** correct method for calculation of mass of CH_3CH_2COONa

OR

Explanation of how pH changes in a buffer when OH^- is added

OR

Method for the calculation of $[H^+]$ and a simplistic explanation of how pH changes in a buffer when OH^- is added

OR

ALLOW *use of HA and* A^-

Calculation of concentrations

$[H^+] = 10^{-pH} = 10^{-4.85}$

$= 1.4(125375...) \times 10^{-5}$ mol dm^{-3}

$[CH_3CH_2COO^-]$

$$= \frac{K_a \times [CH_3CH_2COOH]}{[H^+]}$$

$$= \frac{1.32 \times 10^{-5} \times 0.180}{1.4(125) \times 10^{-5}}$$

$= 0.168(208)$ mol dm^{-3}

OR 0.16971... mol dm^{-3} if 1.4×10^{-5} used

This method could be contained within the working for the mass calculation

Calculation of mass

$n(CH_3CH_2COO^-) = 0.168 \times 0.125$

$= 0.0210(26)$ (mol)

$n(CH_3CH_2COONa) = n(CH_3CH_2COO^-)$

$M_r = 96.0$

$m(CH_3CH_2COO^-) = 0.0210(26) \times 96.0$

$= 2.02$ g **OR** 2.018 g

ALLOW *range 2.00 g to 2.04 g*

ALLOW *alternative methods that lead to correct mass.*

Action of buffer

OH^- from addition of alkali:

$H^+ + OH^- \rightarrow H_2O$

OR

$CH_3CH_2COOH + OH^- \rightarrow CH_3CH_2COO^- + H_2O$

OR

OH^- reacts with H^+ / CH_3CH_2COOH / (propanoic) acid

Attempts the calculation of concentration and mass with a simplistic explanation

There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.

0 marks

No response or no response worthy of credit.

[6 marks]

$CH_3CH_2COOH \rightleftharpoons H^+ + CH_3CH_2COO^-$

ALLOW $HA \rightleftharpoons H^+ + A^-$

equilibrium shifts to the right / (acid) further dissociates restoring $[H^+]$

therefore only a small change in $[H^+]$

minimising change in $[CH_3CH_2COOH]$ / $[CH_3CH_2COO^-]$

Examples of the communication statement for all levels being met could typically include:

- clear mathematical working and appropriate units for calculated values
- use of full chemical formulae in equilibrium rather than HA / A^-

---

Alternative approach

Henderson–Hasselbalch (HH)

ALLOW *use of 2 SF up to calculator value*

$$pH = pK_a + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$$

OR $$= pK_a - \log \frac{[CH_3CH_2COOH]}{[CH_3CH_2COO^-]}$$

e.g.

$4.85 = 4.879426069 + \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$

$-0.029426069 = \log \frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]}$

$\frac{[CH_3CH_2COO^-]}{[CH_3CH_2COOH]} = 0.934884354$

$n(CH_3CH_2COO^-) = 0.934(884354) \times 0.125 \times 0.18$

$= 0.0210259898$

	$m(CH_3CH_2COO^-)$ = 0.0210259898 x 96 = 2.01849502 = 2.02 g

Q9 · November 2020 · Paper 1 (Periodic table, elements and physical chemistry) · Q11 · [1 mark]

Answer: **D**

1.48

Source: OCR A-Level Chemistry A past papers. Reproduced for revision at whiteboardchemistry.com.

Stuck on any of these? One-to-one online A-Level chemistry tuition with Joe White, an experienced examiner: whiteboardchemistry.com/tuition