*See back cover for an English translation of this cover*

3

**91392M**

913925

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

**QUALIFY FOR THE FUTURE WORLD**
**KIA NOHO TAKATŪ KI TŌ ĀMUA AO!**

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Tohua tēnei pouaka mēnā KĀORE koe i tuhituhi i roto i tēnei pukapuka

# Te Mātauranga Matū, Kaupae 3, 2021

## 91392M Te whakaatu māramatanga ki ngā mātāpono taurite i ngā pūnaha waiwai

Ngā whiwhinga: Rima

| Paetae | Kaiaka | Kairangi |
|---|---|---|
| Te whakaatu māramatanga ki ngā mātāpono taurite i ngā pūnaha waiwai. | Te whakaatu māramatanga hōhonu ki ngā mātāpono taurite i ngā pūnaha waiwai. | Te whakaatu māramatanga matawhānui ki ngā mātāpono taurite i ngā pūnaha waiwai. |

Tirohia mēnā e rite ana te Tau Ākonga ā-Motu (NSN) kei runga i tō puka whakauru ki te tau kei runga i tēnei whārangi.

**Me whakamātau koe i ngā tūmahi KATOA kei roto i tēnei pukapuka.**

He taka pūmotu me ētahi atu rauemi tautoko kei te Pukapuka Rauemi L3–CHEMMR.

Ki te hiahia koe ki ētahi atu wāhi hei tuhituhi whakautu, whakamahia te wāhi wātea kei muri i te pukapuka nei.

Tirohia mēnā e tika ana te raupapatanga o ngā whārangi 2 – 17 kei roto i tēnei pukapuka, ka mutu, kāore tētahi o aua whārangi i te takoto kau.

Kaua e tuhi ki roto i tētahi wāhi kauruku whakahāngai (✂✂). Ka tapahia pea tēnei wāhi ina mākahia te pukapuka.

**ME HOATU RAWA KOE I TĒNEI PUKAPUKA KI TE KAIWHAKAHAERE Ā TE MUTUNGA O TE WHAKAMĀTAUTAU.**

## TŪMAHI TUATAHI

(a) (i) Tuhia te whārite mō te tauritenga kei roto i tētahi mehanga kōhura o te konupora waihā, $Mg(OH)_2$.

(ii) Tuhia te kīanga mō te $K_s(Mg(OH)_2)$.

(iii) Tātaihia te mehamehatanga o te $Mg(OH)_2$ i rō wai i te 25 °C, ka homai i te $[Mg^{2+}]$ me te $[OH^-]$.

$K_s(Mg(OH)_2) = 7.10 \times 10^{-12}$

(b) Ina tāpirihia te konutai waihā waimeha, NaOH, ki te mehanga kōhura o te $Mg(OH)_2$, ka heke te kukūtanga o ngā katote $Mg^{2+}$ kei te mehanga kōhura.

(i) Whakamāramatia, mā te whakamahi i ngā mātāpono taurite, he aha te take ka heke te kukūtanga o ngā katote $Mg^{2+}$ i te mehanga kōhura ina ka tāpirihia te NaOH.

(ii) Tātaihia te kukūtanga o ngā katote $Mg^{2-}$ i rō mehanga whai muri i te tāpiri i te 30.0 mL o te mehanga 0.120 mol $L^{-1}$ NaOH ki te 20.0 mL o tētahi mehanga $Mg(OH)_2$ kōhura.

Me kī, he mea iti noa te kukūtanga o ngā katote $OH^-$ kei te mehanga kōhura taketake o te $Mg(OH)_2$.

(c) Whakatauria mēnā ka puta he huatoka o te $Mg(OH)_2$ ina tāpirihia te 65.0 mL o te 0.240 mol $L^{-1}$ o te konupora pākawa ota, $Mg(NO_3)_2$, ki te 40.0 mL o te mehanga NaOH he 12.8 te pH.

## QUESTION ONE

(a) (i) Write the equation for the equilibrium occurring in a saturated solution of magnesium hydroxide, $Mg(OH)_2$.

(ii) Write the expression for $K_s(Mg(OH)_2)$.

(iii) Calculate the solubility of $Mg(OH)_2$ in water at 25 °C, and give $[Mg^{2+}]$ and $[OH^-]$.

$K_s(Mg(OH)_2) = 7.10 \times 10^{-12}$

(b) When dilute sodium hydroxide, NaOH, is added to a saturated solution of $Mg(OH)_2$, the concentration of $Mg^{2+}$ ions in the saturated solution decreases.

(i) Explain, using equilibrium principles, why the concentration of $Mg^{2+}$ ions in the saturated solution decreases upon the addition of NaOH.

(ii) Calculate the concentration of $Mg^{2+}$ ions in a solution after 30.0 mL of 0.120 mol $L^{-1}$ NaOH is added to 20.0 mL of a saturated $Mg(OH)_2$ solution.

Assume the concentration of $OH^-$ ions in the original saturated solution of $Mg(OH)_2$ is insignificant.

(c) Determine whether a precipitate of $Mg(OH)_2$ will form when 65.0 mL of 0.240 mol $L^{-1}$ magnesium nitrate, $Mg(NO_3)_2$, is added to 40.0 mL of NaOH solution of pH 12.8.

## TŪMAHI TUARUA

(a) Ka hangaia he mehanga whakatautika (buffer solution) mā te whakaranu i ngā rahinga tōtika o te waikawa mewaro, HCOOH, me te konutai mehākawa, HCOONa.

$K_a(\text{HCOOH}) = 1.82 \times 10^{-4}$ $\quad$ $pK_a(\text{HCOOH}) = 3.74$

(i) Ina tāpirihia he rahinga iti o te konutai waihā waimeha, NaOH, ki te mehanga whakatautika, ka pā mai te tauhohenga e whai ake:

$$\text{HCOOH} + \text{OH}^- \rightarrow \text{HCOO}^- + \text{H}_2\text{O}$$

Whakaahuahia te mahi a tētahi mehanga whakatautika ka whakamārama i te hiranga o tēnei whārite e ai ki te mahi a te mehanga whakatautika.

(ii) Whakamāramahia mai te take kaore e rerekē ake te pH ina tāpirihia te wai ki tētahi mehanga whakatautika.

## QUESTION TWO

(a) A buffer solution is made by mixing appropriate amounts of methanoic acid, HCOOH, and sodium methanoate, HCOONa.

$K_a(HCOOH) = 1.82 \times 10^{-4}$ $\quad$ $pK_a(HCOOH) = 3.74$

(i) When a small volume of dilute sodium hydroxide, NaOH, is added to the buffer, the following reaction occurs:

$$HCOOH + OH^- \rightarrow HCOO^- + H_2O$$

Describe the function of a buffer solution and explain the significance of this equation in terms of the function of the buffer solution.

(ii) Explain why the pH remains unchanged when water is added to a buffer solution.

(iii) Ka hangaia he mehanga whakatautika o te pH 2.93 mā te whakarewa i te 1.65 g HCOONa ki te 250 mL o tētahi mehanga HCOOH.

Tātaihia te kukūtanga o te mehanga HCOOH ka whakamahia hei hanga i taua mehanga whakatautika.

$M$(HCOONa) = 68.0 g mol$^{-1}$

Me kī kāore he panoni ki te rōrahi tapeke.

(b) Kei te HCOOH tētahi p$K_a$ o te 3.74, ina kei te katote haukini mewaro, $CH_3NH_3^+$, he p$K_a$ of 10.6.

Whakatauritea te pH me te kawe iahiko o tētahi mehanga HCOOH me tētahi mehanga haukini mewaro pūhaumāota, $CH_3NH_3Cl$, he ōrite te kukūtanga. Me whakauru te/ngā whārite hāngai ki tō tuhinga.

*Kāore he tātaihanga e hiahiatia.*

(iii) A buffer solution of pH 2.93 is made by dissolving 1.65 g HCOONa in 250 mL of a HCOOH solution.

Calculate the concentration of the HCOOH solution used to make this buffer solution.

$M$(HCOONa) = 68.0 g mol$^{-1}$

Assume there is no change in the total volume.

(b) HCOOH has a p$K_a$ of 3.74, whereas the methylammonium ion, $CH_3NH_3^+$, has a p$K_a$ of 10.6.

Compare the pH and electrical conductivity of HCOOH and methylammonium chloride, $CH_3NH_3Cl$, solutions of equal concentration. Your answer should include relevant equation(s).

*No calculations are necessary.*

## TŪMAHI TUATORU

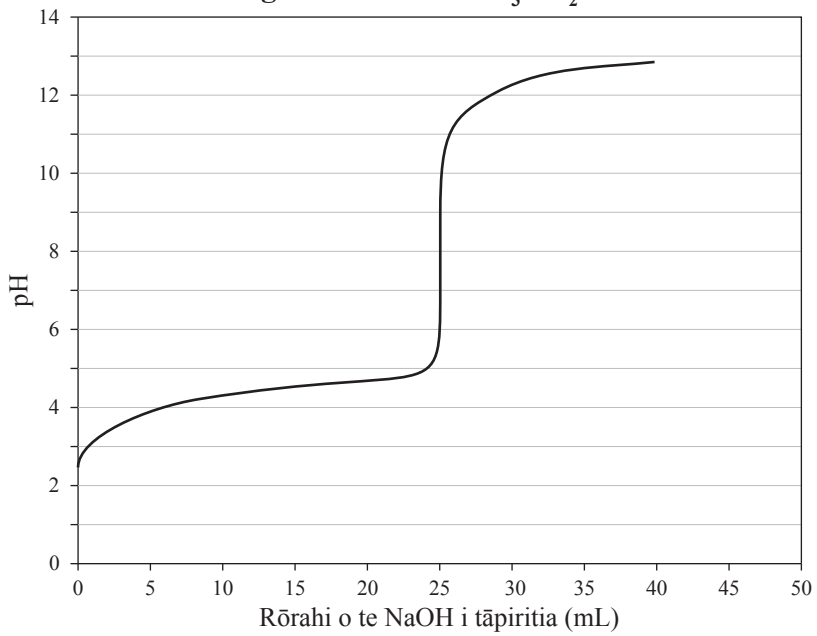
I whakahaerehia he tātairanga kukū mā te tāpiri i te konutai waihā 0.163 mol $L^{-1}$, NaOH, ki te 20.0 mL o te mehanga waikawa pōwaro, $CH_3CH_2COOH$, i roto i tētahi puoto koeko.

Ko te whārite mō te tauhohenga ko:

$$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$$

$K_a(CH_3CH_2COOH) = 1.35 \times 10^{-5}$ $\quad$ $pK_a(CH_3CH_2COOH) = 4.87$

**Te ānau tātairanga kukū mō te $CH_3CH_2COOH$ ki te NaOH**




(a) (i) Whakakīa ngā tapawhā kei raro hei whakaatu i ngā momo katoa kei roto i tētahi mehanga o te waikawa pōwaro ki te raupapa kukūtanga whakaheke.

Kaua e whakaatu i te wai.

| | > | | = | $H_3O^+$ | > | |
|---|---|---|---|---|---|---|

(ii) Ko te pH o te mehanga waikawa pōwaro he 2.78 i mua i te tāpiritanga o te NaOH.

Whakaaturia mā te tātai, ko te kukūtanga tīmata o te waikawa pōwaro he 0.204 mol $L^{-1}$.

(b) (i) Raua he rīpeka ki te pae ōritenga kei te ānau tātairanga kukū o te whārangi 10.

(ii) Kia KOTAHI te tohu hei hoatu ki te tapawhā i raro hei kōwhiri i te tūtohu tika rawa mō te tātairanga.

| **Tūtohu** | **p$K_a$** | **TOHUA (✔) te tūtohu tika rawa** |
|---|---|---|
| Kahurangi Taimoro (Thymol) | 1.70 | |
| Kōwhai mewaro | 3.10 | |
| Kahurangi Naira (Nile) | 9.70 | |

Whakamāramahia mai tō kōwhiringa, me ngā mutunga iho o te kōwhiri i ētahi atu tūtohu.

(iii) Tātaihia te pH kei te pae ōritenga.

*Ka haere tonu te Tūmahi Tuatoru i te whārangi 14.*

## QUESTION THREE

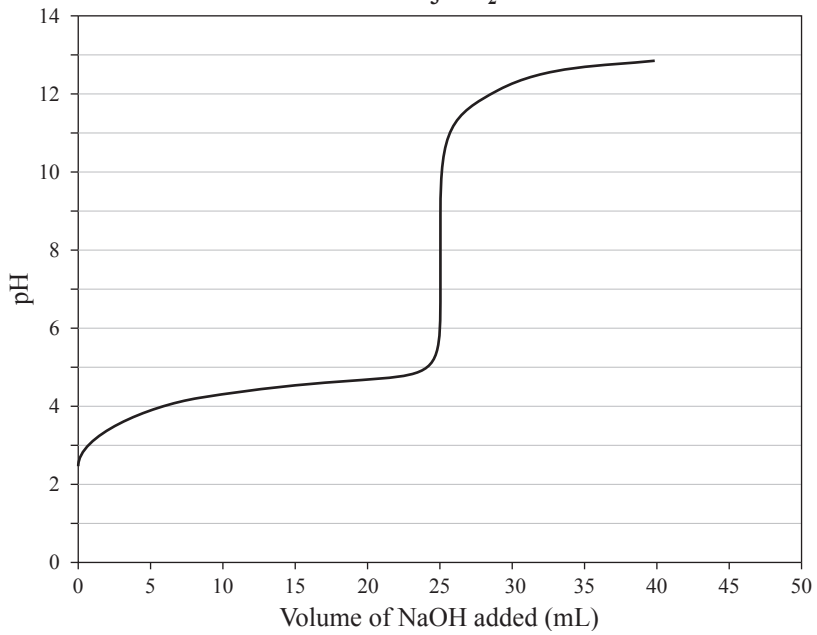
A titration was carried out by adding 0.163 mol $L^{-1}$ sodium hydroxide, NaOH, to 20.0 mL of propanoic acid solution, $CH_3CH_2COOH$, in a conical flask.

The equation for the reaction is:

$$CH_3CH_2COOH + NaOH \rightarrow CH_3CH_2COONa + H_2O$$

$K_a(CH_3CH_2COOH) = 1.35 \times 10^{-5}$ $\quad$ $pK_a(CH_3CH_2COOH) = 4.87$

**Titration curve for $CH_3CH_2COOH$ with NaOH**




(a) (i) Fill in the boxes below to show all the species present in a solution of propanoic acid in order of decreasing concentration.

Do not include water.

| | > | | = | $H_3O^+$ | > | |
|---|---|---|---|---|---|---|

(ii) The propanoic acid solution has a pH of 2.78 before any NaOH is added.

Show, by calculation, that the initial concentration of the propanoic acid is 0.204 mol $L^{-1}$.

(b) (i) Put a cross at the equivalence point on the titration curve on page 12.

(ii) Put ONE tick in the table below to choose the most suitable indicator for the titration.

| Indicator | p$K_a$ | TICK (✔) most suitable indicator |
|---|---|---|
| Thymol blue | 1.70 | |
| Methyl yellow | 3.10 | |
| Nile blue | 9.70 | |

Explain your choice, including the consequences of choosing the other indicators.

(iii) Calculate the pH at the equivalence point.

*Question Three continues on page 15.*

(c) (i) Tātaihia te pH o te mehanga kei te puoto koeko i muri i te tāpiri i te 29.0 mL o te mehanga NaOH.

(ii) Ko te pH o te mehanga 0.163 mol $L^{-1}$ NaOH tuatahi i te ngōine katirere he 13.2.

Whakamāramahia mai he aha i rerekē ai tēnei mai i te pH kua tātaihia i te wāhanga (i) i runga ake.

*Kāore he tātaihanga e hiahiatia.*

(c) (i) Calculate the pH of the solution in the conical flask after 29.0 mL of the NaOH solution has been added.

(ii) The original 0.163 mol $L^{-1}$ NaOH solution in the burette has a pH of 13.2.

Explain why this is different from the pH calculated in part (i) above.

*No calculations are necessary.*

**He whārangi anō ki te hiahiatia.**
**Tuhia te (ngā) tau tūmahi mēnā e tika ana.**

TAU TŪMAHI

**Extra space if required.**
**Write the question number(s) if applicable.**

QUESTION NUMBER

*English translation of the wording on the front cover*

# Level 3 Chemistry 2021

## 91392M Demonstrate understanding of equilibrium principles in aqueous systems

Credits: Five

91392M

| Achievement | Achievement with Merit | Achievement with Excellence |
|---|---|---|
| Demonstrate understanding of equilibrium principles in aqueous systems. | Demonstrate in-depth understanding of equilibrium principles in aqueous systems. | Demonstrate comprehensive understanding of equilibrium principles in aqueous systems. |

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

**You should attempt ALL the questions in this booklet.**

A periodic table and other reference material are provided in the Resource Booklet L3–CHEMMR.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2 – 17 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (▨). This area may be cut off when the booklet is marked.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.**