VICTORIAN CURRICULUM
AND ASSESSMENT AUTHORITY

2017 VCE Chemistry (NHT) examination report

Specific information

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

Section A – Multiple-choice questions

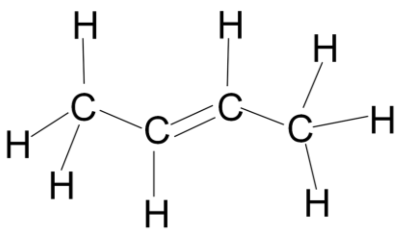
Question	Answer	Comments
1	A	Titration curve implies that a strong acid has been added (from a burette) to a weak base. Equivalence point around 4.5 would be best picked up using methyl red.
2	B	$K(+1)Mn(+7)O(-2)_4$
3	C	Methyl (CH_3) and chloro(Cl) groups are both on C-2 of a butane (4 C) backbone.
4	D	NaOH pellets absorb moisture and react with atmospheric CO_2.
5	B	Acids can interact with ionic salt bridges in the tertiary structure and might, depending on the acid, affect hydrogen bonds in the secondary and tertiary structures.
6	D	Graph Z shows a lower activation energy compared to Graph Y. Hence catalyst added.
7	D	Energy released so the enthalpy of the products is lower than the enthalpy of the reactants.
8	A	Since compound reacts with acid, it must be either $CH_3CH_2CH_2COOH$ or $(CH_3)_2CHCOOH$. While both $[COOH]^+$ and $[CH_3CH_2O^-]^+$ are both consistent with $m/z = 45$, only $[COOH]^+$ is consistent with the compound being an acid.
9	A	Technique most suited to high boiling temperature species such as peptides.
10	D	
11	C	Adding an inert gas has no effect on the equilibrium since the ratio $\{[NH_3]^2/[N_2][H_2]^3\}$ is not affected and remains equal to K.
12	B	Increasing total volume decreases the reactant concentrations and so the forward reaction, and the rate at which equilibrium is reached, slows down.
13	C	According to the thermochemical, reaction of 2 mol (hence 48.6 g) of Mg releases 1200 kJ.
14	D	$2HNO_3(aq) + Ba(OH)_2(aq) \rightarrow BaCl_2(aq) + 2H_2O(l)$ Initially 0.04 mol 0.01 mol *Reacting 0.02 mol 0.01 mol* Remaining 0.02 mol -

		0.02 mol $HNO_3(aq)$ in excess $\rightarrow$ 0.02 mol $H^+(aq)$ in excess $[H^+]$ = 0.02 mol/0.200 L = 0.1 M pH = 1.0
15	A	Temperature, carrier gas flow rate and molecular mass all affect relative extent of interaction with the stationary phase. The length of the column does not affect the relative interaction.
16	D	$CH_3COOH(l) + CH_3CH_2CH_2OH(l) \rightarrow CH_3COOCH_2CH_2CH_3(l) + H_2O(l)$ Propyl ethanoate
17	A	$Cl_2(g) + 2e^- \rightleftharpoons 2Cl^-(aq)$ 1.36 V $Cu^{2+}aq) + 2e^- \rightleftharpoons Cu(s)$ 0.34 V Cu(s) is oxidised to $Cu^{2+}(aq)$ at the anode (–), so electrons then move onto the Pt electrode where $Cl_2(g)$ is reduced to $Cl^-(aq)$. Initial cell voltage is 1.02 V (1.36 – 0.34) and this slowly drops as the half-equations proceed and current flows.
18	B	Cu electrode deteriorates as oxidation occurs at the electrode. $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$
19	A	Since all the alcohols have a hydroxy (–OH) functional group, molecular size is a key factor in attraction to the stationary phase. Hence the second-largest molecules, those of butanol, will have the second-highest retention time.
20	C	$m(C_{17}H_{30}ClN)$ in 1 L disinfectant = (1.5/100) × 1000 = 15 g $n(C_{17}H_{30}ClN)$ in 1 L disinfectant = 15/283.5 = 5.29×10^{-2} mol The disinfectant is diluted by a factor of 21 – 1 part disinfectant added to 20 parts of water. $n(C_{17}H_{30}ClN)$ in 1 L diluted disinfectant = $5.3 \times 10^{-2}/21 = 2.5 \times 10^{-3}$ mol $c(C_{17}H_{30}ClN)$ in 1 L diluted disinfectant = 2.5×10^{-3} mol L^{-1}
21	B	Equivalence point at approximately pH 4. The best indicator option (of those available) is methyl orange.
22	D	All concentrations instantaneously increase and then the system moves to the side with fewer particles.
23	D	$\Delta H_c(CH_3OH) = –725$ kJ mol^{-1} (Data Book) Heat of combustion = 725/32.0 = 22.7 kJ g^{-1}
24	C	Since metal X is a reductant that reacts with $Cu^{2+}(aq)$, $Fe^{3+}(aq)$ and $Ni^{2+}(aq)$, it must be lower on the electrochemical series than all three species. $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ 0.77 V $Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$ 0.34 V $\rightleftharpoons$ $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$ –0.25 V $Fe^{2+}(aq) + 2e^-$ Fe(s) –0.44 V
25	A	$n(SO_4^{2-})$ added = $n(H_2SO_4) = cV$ = 0.75 × 0.025 = 0.01875 mol $n(SO_4^{2-})$ precipitated = $n(BaSO_4)$ = 2.43 g/233.4 g mol^{-1} = 0.0104 mol $n(SO_4^{2-})$ in filtrate = 0.01875 – 0.0104 = 0.00835 mol V(filtrate) = 20.0 + 25.0 = 45.0 mL $c(SO_4^{2-})$ in filtrate = 0.00835 mol/0.45 L = 0.19 mol L^{-1}

26	B	Ethanol is oxidised to ethanal.
27	A	Half-equations for reactions at the electrodes are Anode (+) $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ Cathode (–) $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$
28	A	Half-equations for reactions at the electrodes are Anode (+) $Ag(s) \rightarrow Ag^+(aq) + e^-$ Cathode (–) $Ag^+(aq) + e^- \rightarrow Ag(s)$
29	B	$n(Ag)$ required = 0.75/107.9 = 0.00695 mol Total Q required = $n(e^-)$ x F = 0.00695 × 96500 = 671 C Q provided at 0.75 A for 10 minutes = It = 0.75 × 10 × 60 = 450 C Q required at 1.00 A = 671 – 450 = 221 C $t = Q/I$ = 221/1.00 = 221 seconds t = 220 s (two significant figures)
30	C	

Section B

Question 1ai.



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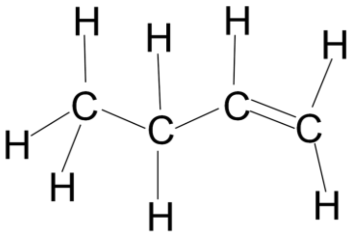


Question 1aii.

2-chlorobutane

Question 1aiii.

$CH_3CH_2CH(NH_2)CH_3$

2-butanamine or 2-butylamine or butan-2-amine

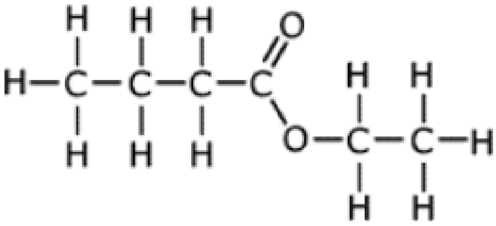
Question 1bi.

$C_4H_9OH + H_2O(l) \rightarrow C_3H_7COOH + 4H^+ + 4e^-$

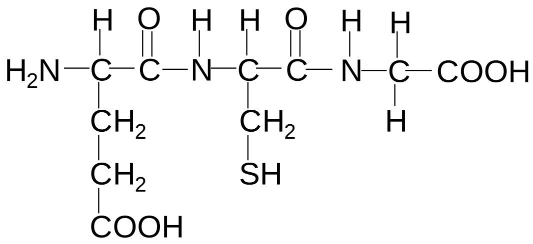
Question 1bii.

Ethyl butanoate

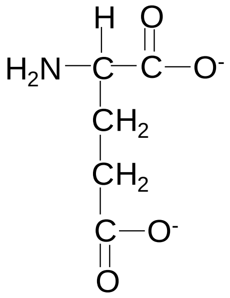
Question 1biii.



Question 2a.



Question 2b.



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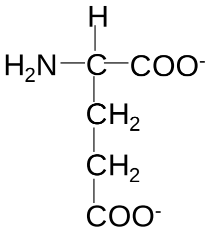


Question 2c.

At high temperatures:

- the enzyme would be denatured as its tertiary structure is disrupted
- the shape of the active site is changed and catalytic action is lost
- the substrate is no longer able to bond to the active site of the enzyme and so the reaction is no longer catalysed.

Question 3a.

C=0, 1750 cm^{-1} (1670–1750 cm^{-1}) or C-H, 3000 cm^{-1} (2850–3300 cm^{-1})

Question 3b.

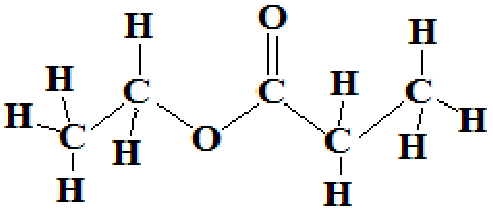
Four/4

Question 3c.

Appropriate responses included:

- The molecule contains 2 CH_3CH_2– groups.
- The splitting patterns (3 peaks) at δ = 1.1 ppm and δ = 1.3 ppm both suggest two instances of the presence of 2 H atoms on a neighbouring C atom.
- The splitting patterns (4 peaks) at δ = 2.3 and δ = 4.1 both suggest two instances of the presence of 3 H atoms on a neighbouring C atom.

Question 3d.



The ^{13}C NMR spectrum shows five peaks consistent with the five different C environments shown in the structure.

One mark each was awarded for:

- ester linkage drawn correctly
- two ethyl groups correctly attached to the ester group
- linking 5 peaks on the ^{13}C NMR spectrum to 5 different C environments.

Question 4a.

UV-visible spectroscopy

Question 4b.

595 nm

The wavelength chosen is one with maximum absorbance by the dye bound to the protein, with minimal absorption by the dye itself.

Question 4ci.

340 μg mL^{-1} (330–355μg mL^{-1})

Question 4cii.

c(protein) in solution = 340 μg mL^{-1}

m(protein) in 1.5 mL liver = m(protein in 10.00 mL solution)

= 10 mL^{-1} × 340 μg mL^{-1}

= 3.4 × 10^{3} μg

= 3.4 mg

c(protein in liver) = 3.4 mg/1.5 mL

= 2.3 mg mL^{-1}

One mark each was awarded for:

- m(protein) in 10 mL solution/1.5 mL liver
- accurate calculation of c(protein) in liver.

Question 5a.

Cu electrode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$

Fe electrode: $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

Question 5b.

Copper (Cu)

Question 5ci.

0.44 V

Question 5cii.

Acceptable responses included:

- The setup was not at standard conditions.
- The $c(H^+)$ in a lemon is not 1.0 M; the temperature was not set at 25 °C.
- Other reactions may have been occurring in the lemon.

Question 5d.

From Al (aluminium) to Fe (iron), i.e. electron flow will reverse and either:

- Al is a stronger reductant than Fe and so will be the site of oxidation
- Al is oxidised, and $H^+(aq)$ is reduced at the Fe.

Question 6ai.

$n(NaOH)$ in titre $= 0.1123 \times 25.60 \times 10^{-3}$

$= 2.875 \times 10^{-3}$ mol

$n(CH_3COOH)$ in 20.00 mL aliquot $= 2.875 \times 10^{-3}$ mol

$n(CH_3COOH)$ in 10.00 mL vinegar

$= n(CH_3COOH)$ in 100.00 mL flask

$= 2.875 \times 10^{-3} \times (100/20)$

$= 1.437 \times 10^{-2}$ mol

$c(CH_3COOH)$ in vinegar $= 1.437 \times 10^{-2}/10.00 \times 10^{-3}$

$= 1.437$ mol L^{-1}/1.437 M

Question 6aii.

Calculated $c(CH_3COOH)$ would be higher.

Water remaining in the burette dilutes the NaOH(aq) added to it, and so a larger volume of NaOH/larger titre is required to reach the endpoint of the reaction.

Question 6bi.

Either:

$CH_3COOH(l) + H_2O(l) \rightleftharpoons CH_3COO^-(aq) + H_3O^+(aq)$

$CH_3COOH(l) \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$

Question 6bii.

One of:

- $K_a = [CH_3COO^-][H_3O^+] / [CH_3COOH]$
- $K_a = [CH_3COO^-][H^+] / [CH_3COOH]$
- $[CH_3COO^-][H_3O^+] / [CH_3COOH]$
- $[CH_3COO^-][H^+] / [CH_3COOH]$

Question 6c.

$K_a = [CH_3COO^-][H_3O^+] / [CH_3COOH]$

Since $K_a = 1.7 \times 10^{-5}$, assuming $[CH_3COO^-] = [H_3O^+]$

$1.7 \times 10^{-5} = [H_3O^+]^2/[CH_3COOH$

$[CH_3COOH] = [H_3O^+] /1.7 \times 10^{-5}$

$= (10^{-2.9})^2/1.7 \times 10^{-5}$

$= 1.5$ M

Question 6d.

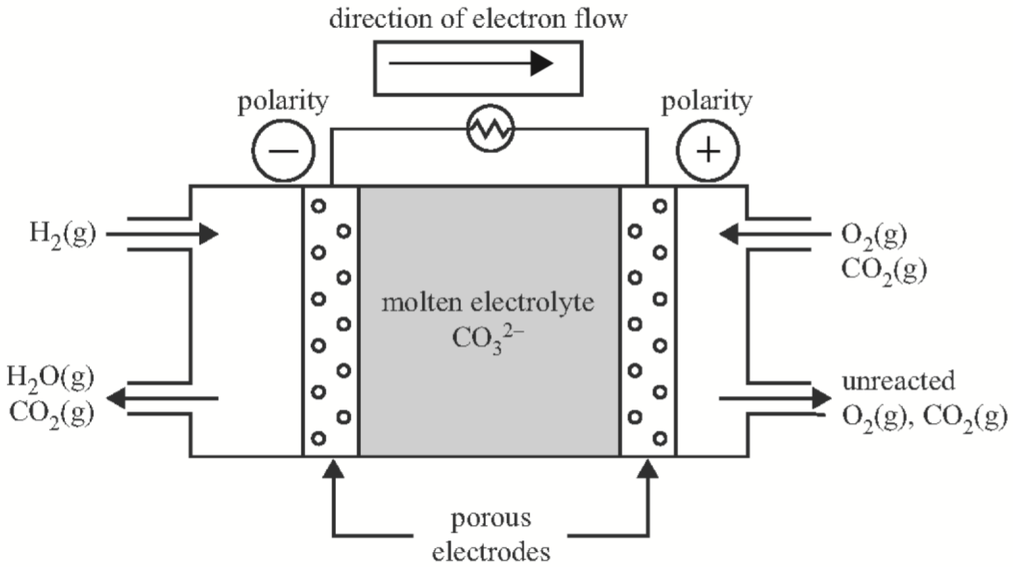
- Error in preparation or transfer of the vinegar sample, e.g. not all the vinegar was transferred to the volumetric flask or volumetric flask was filled above calibration mark.
- Systematic error in the volumetric analysis, e.g. pipette used to transfer the original sample transferred less than 10.00 mL/pipette rinsed with NaOH(aq).
- The pH may have been measured at a temperature higher than 25 °C, so the $[H_3O^+]$ calculated $[CH_3COOH]$ will be larger.

Question 6e.

% ionisation will increase and one of:

- Dilution decreases the ratio $[CH_3COO^-][H_3O^+] / [CH_3COOH]$ relative to K_a, so the equilibrium moves to the right.
- Since the $[H_2O]$ is constant the system moves to produce more particles in the larger volume, so forward reaction favoured.
- Dilution decreases total product concentration – rate of the reverse reaction more than reactant concentration – rate of the forward reaction. Forward reaction is favoured to return to equilibrium (where rates are equal) and so % ionisation increases.

Questions 7ai. and 7aii.



Question 7b.

One of:

- Fuel cell is more efficient.
- Fuel cell (MCFC) does not have a net overall release of CO_2 .
- Fuel cell uses renewable H_2, whereas petrol, a fossil fuel, is not renewable.

Question 7ci.

Either:

- $CO_2 + ½O_2 + 2e^- \rightarrow CO_3^{2-}$
- $2CO_2 + O_2 + 4e^- \rightarrow 2CO_3^{2-}$

Question 7cii.

$n(O_2) = ½ \times n(CO_3^{2-}) = ½ \times 11.50$

$= 5.75$ mol

$V(O_2) = n(O_2) \times RT / P$

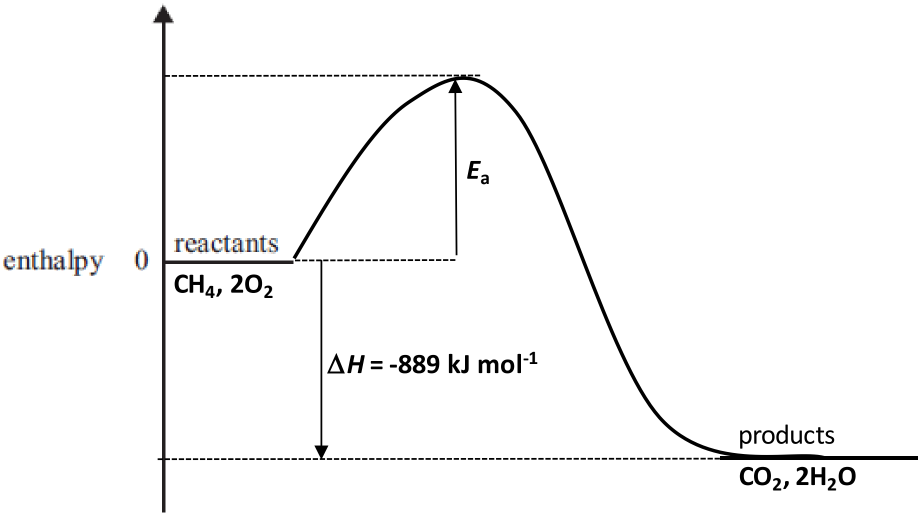
$= 5.75 \times 8.31 \times (665 + 273) / (2.5 \times 101.3)$

$= 177$ L

Question 8a.

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$; $\Delta H = –889$ kJ mol$^{–1}$

Question 8b.



One mark each was awarded for correct:

- shape
- representation of ΔH as difference between product and reactant enthalpies.
- representation of activation energy.

Question 8c.

$m(CH_4) = 0.78 \times 100$

$= 78.0$ kg

$n(CH_4) = 78.0 \times 10^3/16.0$

$= 4.88 \times 10^2$ mol

Energy available = 4.88×10^2 mol × 889 kJ mol^{-1}

$= 4.33 \times 10^6$ kJ

Question 8d.

Advantages

- Biogas is a renewable energy source.
- Biogas can be produced from agricultural waste.
- Reduces atmospheric CH_4 from waste agricultural waste decay.

Disadvantages

- CO_2 produced in combustion is a greenhouse gas.
- $H_2O(g)$ produced is a greenhouse gas.
- Since biogas is only 78% methane, other pollutants such as $SO_2(g)$ may be produced during its combustion.

Question 9a.

Purple colour lightens since the $[I_2]$ decreases as the forward reaction proceeds and colourless HI is produced.

Colour stops changing after 30 minutes because equilibrium has been established and the forward and reverse reactions are proceeding at the same rate / $I_2(g)$ is being consumed and produced at the same rate.

Question 9b.

One of:

- Use a higher initial temperature: This will increase the initial reaction rate since the number of collisions per unit time (frequency of collisions) and the proportion of collisions that are successful will increase.
- Add a catalyst: This will increase the initial reaction rate since it will lower the activation energy and increase the proportion of collisions that are successful.
- Use a smaller container/decrease volume: This will increase the initial reaction rate since reactant concentration will be higher, and the number of collisions and successful collisions per unit time will increase.

Question 9c.

- Heat the gas mixture to a constant 280 °C. Assume the volume remains constant
  Gas mixture will be lighter.
  The forward reaction is endothermic, so the forward reaction will be favoured as the system moves to partially oppose the energy increase. Hence the concentration of purple I_2 will decrease.

One mark each was awarded for:

- effect on colour of gas mixture.
- explanation of the system response to temperature increase.
- effect on I_2 concentration.

- Restore the temperature of the gas mixture to 232 °C. Increase the volume of the container to 1.5 L at a constant temperature of 232 °C.

  Gas mixture will be lighter.
  Although the pressure decreases the system cannot move to increase the pressure (increase the number of particles) since there are the same number of particles on both sides. However, the concentration of purple I_2 decreases due to the volume increase.

One mark each was awarded for:

- effect on colour of gas mixture
- explanation of the system response to volume increase
- effect on I_2 concentration.

- Restore the volume of the container to 1.0 L. Inject some HI into the container at a constant temperature of 232 °C.

  Gas mixture will be darker.
  System will move to partially oppose the addition of the product HI by favouring the reverse reaction. The concentration of purple I_2 increases and so the gas mixture will be darker at the new equilibrium.

One mark each was awarded for:

- effect on colour of gas mixture
- explanation of the system response to addition of HI
- effect on I_2 concentration.

Question 10a.

$E = VIt = 5.80 \times 4.50 \times 300$

$= 7.83 \times 10^3$ J

$CF = E/\Delta T = 7.83 \times 10^3/(25.23 - 22.53)$

$= 2.90 \times 10^3 \text{ J } ^\circ\text{C}^{-1}$

$= 2.90 \text{ kJ } ^\circ\text{C}^{-1}$

Question 10b.

Energy released $= \text{CF} \times \Delta T$

$= 2.90 \times (35.15 - 23.83)$

$= 32.8$ kJ

Question 10c.

$n(C_{13}H_{26}O_2) = 0.905/214.0$

$= 4.23 \times 10^{-3}$ mol

Energy released per mol $= 32.8$ kJ / 4.23×10^{-3} mol

$= 7.76 \times 10^3$ kJ mol^{-1}

$\Delta H_c = -7.76 \times 10^3$ kJ mol^{-1} (-7760 kJ mol^{-1})

Question 10d.

$\Delta H = -1.55 \times 10^4$ kJ mol^{-1} (-15500 kJ mol^{-1})

Question 11

Assumption

- The only source of Na^+ in the chips was NaCl.
- The only source of Cl^- in the chips was NaCl.
- All the NaCl dissolved into aqueous solution in separating funnel.
- All the Cl^- was precipitated as AgCl.
- The AgCl collected was completely dry.

All the precipitate was collected.

Modification	**Justification**
Test filtrate remaining after AgCl precipitation for the presence of Cl^- ions.	Ensure all the Cl^- has precipitated been collected as AgCl and reduce the likelihood of a lower than true NaCl content.
Weigh and gently reheat the precipitate and filter paper until constant mass is obtained.	Ensure the precipitate is dry and reduce the likelihood of a higher than true NaCl content.
Weigh the filter paper prior to collection of the precipitate.	Either: • Allows the dried precipitate to be weighed and the mass of filter subtracted to calculate the *m*(AgCl). • Scraping the precipitate off the filter paper does not ensure complete collection.

Conclusion

Pair F obtained a sodium content (649 mg/100g) consistent with the manufacturer's claim (644 mg/100g) within 0.8%.

All pairs, except the clear outlier, obtained values higher than the manufacturer's claim, perhaps due to their precipitates not being completely dry.

Averaging the results, ignoring the clear outliers C and E, gives a sodium content of 695 mg/100 g, which is within 8% of the manufacturer's claim.

Reasons for difference from manufacturer's claim

The sodium content determined by the majority of pairs, and the average (695 mg /100 g), was higher than the manufacturer's claim. This might be due to:

- KCl also present in the chips (this is very common)
- the precipitate was not completely dry
- the manufacturers do not state the sodium content specific to the bag of chips tested but rather a representative average
- the significantly higher salt content determined by E may have been due to not drying, or incompletely drying the precipitate
- the significantly lower salt content by C could have been caused by a range of errors including, loss of chips in crushing, loss of precipitate, incomplete precipitation, incomplete dissolving of NaCl in water.