N10/4/CHEMI/SP3/ENG/TZ0/XX/M

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# MARKSCHEME

## November 2010

## CHEMISTRY

## Standard Level

## Paper 3

21 pages

**1.** Follow the markscheme provided, award only whole marks and mark only in **RED**.

**2.** Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

**3.** Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation to explain your decision. You are encouraged to write comments where it helps clarity, especially for moderation and re-marking. It should be remembered that the script may be returned to the candidate.

**4.** Unexplained symbols or personal codes/notations are unacceptable.

**5.** Record marks in the right-hand margin against each mark allocation shown in square brackets *e.g.* ***[2]***. The total mark for a question must equal the number of ticks for the question.

**6.** Do **not** circle sub-totals. **Circle the total mark** for the question in the right-hand margin **at the end of the question.**

**7.** Where an answer to a part question is worth no marks, put a zero in the right-hand margin next to the square bracket.

**8.** Where work is submitted on additional sheets the marks awarded should be shown as ticks and a note made to show that these marks have been transferred to the appropriate square bracket in the body of the script.

**9.** For each option: Add the totals for each question in the option and write it in the Examiner column on the front cover.
Total: Add the marks awarded and enter this in the box marked TOTAL in the Examiner column on the cover sheet.

**10.** After entering the marks on the front cover check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the cover sheet. **All scripts are checked and a note of all clerical errors will be given in feedback to examiners.**

**11.** If an answer extends over more than one page and no marks have been awarded on a section draw a diagonal line through that section to indicate that it has been marked.

**12.** If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers and use the marks of those answers that have the highest mark, **unless the candidate has indicated the question(s) to be marked on the front cover**.

**13.** A mark should not be awarded where there is contradiction within an answer. Make a comment to this effect in the left hand margin.

# Subject Details: Chemistry SL Paper 3 Markscheme

## Mark Allocation

Candidates are required to answer questions from **TWO** of the options **[2 × 20 marks]**. Maximum total = **[40 marks]**.

**1.** A markscheme often has more marking points than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

**2.** Each marking point has a separate line and the end is signified by means of a semicolon (;).

**3.** An alternative answer or wording is indicated in the markscheme by a slash (/) - either wording can be accepted.

**4.** Words in brackets ( ) in the markscheme are not necessary to gain the mark.

**5.** Words that are underlined are essential for the mark.

**6.** The order of marking points does not have to be as in the markscheme, unless stated otherwise.

**7.** If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

**8.** Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

**9.** Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. Indicate this with **ECF** (error carried forward).

**10.** Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

**11.** Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

*e.g.* if the answer is 1.63:

| | |
|---|---|
| 2 | *reject* |
| 1.6 | accept |
| 1.63 | accept |
| 1.631 | accept |
| 1.6314 | *reject* |

Indicate the mark deduction by writing **–1(SD)** at the first point it occurs and **SD** on the cover page.

**12.** If a question specifically asks for the name of a substance, do not award a mark for a correct formula, similarly, if the formula is specifically asked for, do not award a mark for a correct name.

**13.** If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.

**14.** Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

**Option A — Modern analytical chemistry**

**A1.** (a) determination of structure
determination of concentrations
identification of substances
*Allow separation of substances.*

analysis of (different) composition of substances/compounds/mixtures
determination of purity of substances
in medicine for body imaging
*Do not allow just in medicine.*

determining illegal drug use
forensic science for evidence in courts
monitoring of the environment
DNA testing
testing foods for levels of sugar / testing quality of food ***[1]***
*Accept other specific examples.*
*Do not award mark for repeating examples given in (b).*
*Award **[1]** for any two.*

(b) (i) paper chromatography / thin layer chromatography / column chromatography / high-performance liquid chromatography/HPLC; ***[1]***

(ii) MS/mass spectrometry/spectroscopy; ***[1]***

(iii) ($^1$H/proton) NMR/nuclear magnetic resonance / MRI/magnetic resonance imaging; ***[1]***

**A2.** (a) (using a rotating mirror) beam of monochromatic radiation / radiation of one frequency/wavelength/wavenumber;
splitter splits (IR) light into two beams (of same wavelength);
which passes through sample **and** reference;
photomultiplier converts radiation/photons into current/signal/voltage (output) / photomultiplier/photodiode used as detector;
absorbance/transmittance of reference compared with/subtracted from absorbance/transmittance of sample / reference used to set baseline / *OWTTE* ;
IR spectrum generated by varying wavelength/frequency/wavenumber / *OWTTE*; ***[3 max]***
*Accept correctly labelled diagram including these points.*

(b) change in bond length / bond stretching / asymmetric stretch;
change in bond angle / bending (of molecule);
*Allow **[1 max]** for only stating vibrations.*

induces molecular polarity/dipole moment / *OWTTE*; ***[3]***

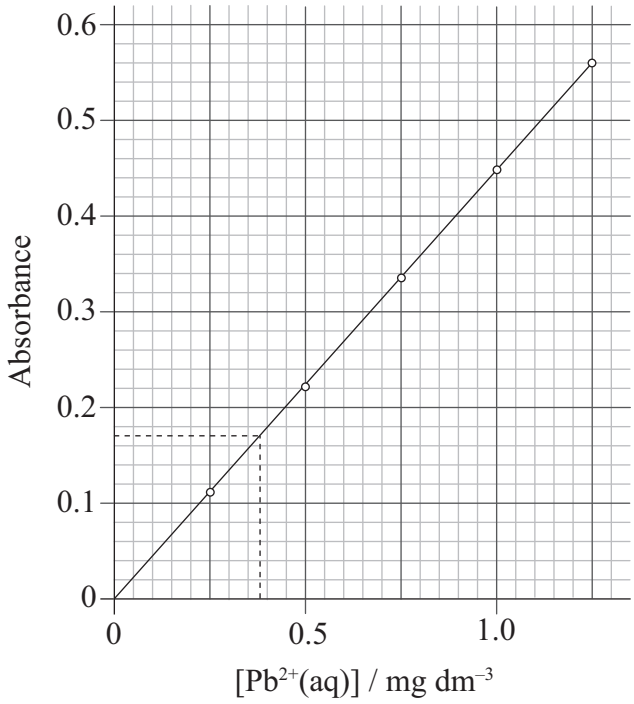
(c) (i) **A**: O–H
**B**: C=O
**C**: C–O ***[2]***
*Award **[2]** for three correct, **[1]** for two correct.*

(ii) *m/z* = 74 : $C_2H_5COOH^+$ / $C_3H_6O_2^+$;
*m/z* = 45 : $COOH^+$;
*m/z* = 29 : $C_2H_5^+$; ***[3]***
*Penalize missing + charge once only.*
*Do not award mark for m/z = 29: $CHO^+$.*

(iii) –COOH; ***[1]***

(iv) $CH_3CH_2COOH$ / $CH_3CH_2CO_2H$; ***[1]***
*More detailed structural formula may be given.*

**A3.** graph of absorbance versus concentration showing all five points plotted **and** connected;
*Do not penalize if graph is not extended to origin.*
*Points should be plotted closest to within one-half of a small square.*




determination of concentration (~ 0.38 mg dm$^{-3}$) corresponding to absorbance of 0.170 ;
*Allow a range of 0.35 to 0.42.*

concentration not within/more than WHO limit / *OWTTE*; ***[3]***

**Option B — Human biochemistry**

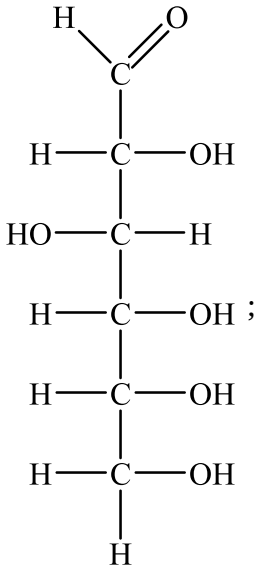
**B1.** (a) $\Delta T = 7.35\,(\mathrm{K}/^{\circ}\mathrm{C})$;

$q\,(= mc\Delta T = 200.10\,\mathrm{g} \times 4.18\,\mathrm{J\,g^{-1}\,K^{-1}} \times 7.35\,\mathrm{K}) = 6.15 \times 10^{3}\,\mathrm{J}$ (per 0.85 g of glucose heated);

energy value $= 7.2 \times 10^{3}\,(\mathrm{J\,g^{-1}})$; ***[3]***

*Award **[3]** for correct final answer.*

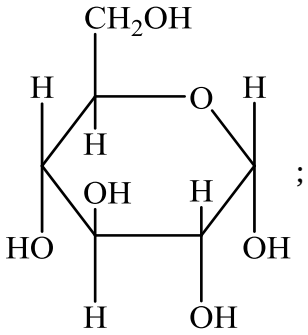
(b) (i)



; ***[1]***

*Accept CHO, $CH_2OH$ and OH groups on either side of the carbon chain provided OH on C3 is on the opposite side to OHs on C2, C4 and C5.*

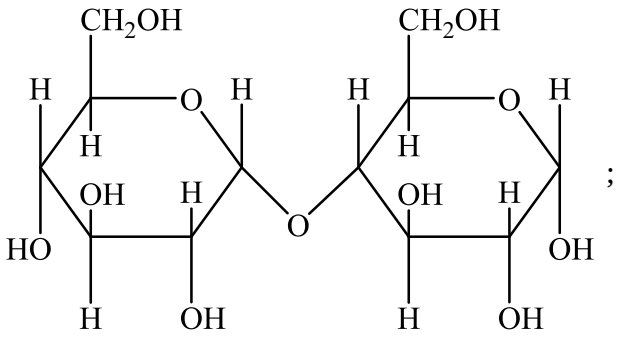
(ii)



; ***[1]***

*Accept $CH_2OH$ and OH groups on either face, as long as OH on C3 is on the opposite face to the OH's on C1, C2 and C4.*
*No mark awarded if $HOCH_2$ is written, with H bonded to C or if HO is written for hydroxyl groups, with H bonded to C. Penalize this once only in (i), (ii) and (iv).*

(iii) the OH on carbon-1/C-1 is inverted / difference in position of OH on carbon-1/C-1; ***[1]***

(iv) 

;

***[1]***

(c) energy reserve / can act as precursors in large number of metabolic reactions/for other biologically important molecules; ***[1]***

**B2.** (a) 2 mol of iodine reacts with 1 mol of linoleic acid;
$M_r = 253.80$ g mol$^{-1}$ for iodine **and** $M_r = 280.50$ g mol$^{-1}$ for linoleic acid;
$\left(\frac{(507.60 \times 100.00)}{280.50} = \right) 180.96\,(g) / 181\,(g)$; ***[3]***
*Award **[3]** for correct final answer.*
*Allow 254 g mol$^{-1}$ for iodine and 281/280 g mol$^{-1}$ for linoleic acid.*
*Award **[2 max]** for incorrect ratio calculation to give answers such as 90.4, 90.481, 90.7 (g) depending on $M_r$ values used.*

(b) less oxidized (compared to carbohydrates) / fewer oxygen atoms (compared to carbohydrates); ***[1]***

(c) C=C's in linoleic acid cause the chain to be more uneven/kinked;
linoleic acid cannot pack as closely as stearic acid;
intermolecular/van der Waal's/London/dispersion forces weaker in linoleic acid; ***[2 max]***
*Accept converse argument for stearic acid.*

**B3.** (a) chemical messenger / chemicals (produced in glands) which are transported through the blood (to the site of action); ***[1]***

(b) (i) alkene;
ketone; ***[2]***
*Accept carbonyl.*

(ii) 21; ***[1]***

(c) treating hormone disorders;
treating testes / increase sperm production;
treating breast cancer;
induce male puberty;
gain weight / building tissue (following illness);
sex change to male; ***[2 max]***

**Option C — Chemistry in industry and technology**

**C1.** *Arguments for*: ***[2 max]***
high energy content / high enthalpy of combustion;
shortage of alternatives;
alternatives are expensive / oil relatively cheap;
well-established technology;
easy to store;
easy to transport;
produces energy at a reasonable rate;

*Arguments against*: ***[2 max]***
chemical feedstock of limited supply/*OWTTE;*
non-renewable;
combustion causes global warming/greenhouse gases;
combustion produces acidic gases; ***[4]***
*Apply* / *OWTTE throughout.*

**C2.** steam cracking;
$C_6H_{14} \rightarrow C_3H_8 + C_3H_6$ ; ***[2]***
*Ignore state symbols.*

**C3.** (a) nanotechnology involves research and technology developments at the 1 nm to 100 nm range;
structures with novel properties (because of their small size) / *OWTTE*;
ability to manipulate on the atomic scale / *OWTTE*; ***[2 max]***
*Overlap here between definition and matters of interest, so accept any two.*

(b) (i) (main) cylinder consists of (carbon) hexagons / *OWTTE*;
pentagons close structures/tubes at ends / *OWTTE*; ***[2]***
*Marks may also be scored by means of a suitable diagram showing above.*

(ii) high tensile strength / low density / high thermal conductivity / (electrical) conductors / (electrical) semi-conductors / high melting points; ***[1]***

(c) health concerns / concern that the human immune system will be defenceless against particles on the nanoscale;
potential toxicity of materials / toxicity regulations are difficult (to apply);
possible explosive nature of large scale manufacture of nanoparticles;
political issues; ***[2 max]***
*Apply / OWTTE throughout.*

**C4.** (a) *Negative electrode (anode)*:
$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$;

*Positive electrode (cathode)*:
$H_2O(l) + \frac{1}{2}O_2(g) + 2e^- \rightarrow 2OH^-(aq)$; ***[2]***

*Allow correct equations involving multiple coefficients (i.e. $2H_2$ etc.).*
*Ignore state symbols.*
*Allow e instead of $e^-$.*
*Award **[1 max]** for correct equations but at incorrect electrodes.*

(b) lithium-ion; ***[1]***

(c) fuel cells need constant supply of reagents/chemicals (when they produce electricity) while rechargeable batteries need occasional supply of electricity / *OWTTE*;
fuel cells fuel supplied continuously while in rechargeable batteries energy stored inside the batteries / *OWTTE*;
products must be constantly removed from a fuel cell;
fuel cells (currently) more expensive;
fuel cells made of chemically more inert materials / *OWTTE*; ***[2 max]***

(d) (potentially) explosive (gas) / flammable;
must be stored/transported in large/heavy containers; ***[2]***

**Option D — Medicines and drugs**

**D1.** (a) hydrochloric acid; ***[1]***

(b) $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$;
$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$; ***[2]***
*Ignore state symbols.*
*Award **[1 max]** for correct reactants and products in both equations if equations are not balanced.*

(c) (i) neutralizes excess stomach acid / produces neutralizing layer;
prevents acid in stomach from rising / prevents acid reflux; ***[2]***

(ii) prevent flatulence/(stomach) bloating / *OWTTE*;
dimethicone / polydimethylsiloxane/PDMS; ***[2]***

**D2.** (a) *Advantage*: ***[1 max]***
does not affect stomach/ulceration/bleeding;
does not give allergic reactions;
does not give Reye's syndrome;

*Disadvantage*: ***[1 max]***
causes blood disorders;
causes kidney damage;
liver damage;
brain damage; ***[2 max]***

(b) (i) amine;
ether;
alkene;
benzene ring; ***[2 max]***
*Do not allow arene.*
*Allow phenyl (ring or group) or benzene.*
Allow structural representation of functional group instead of name (e.g. C=C instead of alkene).

(ii) phenol / alcohol / hydroxyl (group); ***[1]***
*Allow OH.*

(iii) (di)esterification / condensation / (di)acetylation; ***[1]***

**D3.**

| *Sociocultural issue* | *Valid points related to the chosen sociocultural issue* |
|---|---|
| Condom use; | availability / cost<br>cultural resistance |
| Cultural factors; | ignorance<br>wishful thinking<br>misinformation<br>social stigma |
| Illegal activities; | drug use<br>prostitution<br>impact of wars |
| Resources / medical factors; | availability of medical services<br>cost of drugs<br>condom use |
| Orphans; | resources / cost<br>devastation of family life |
| Devastation of family life; | resources / cost<br>orphans |

***[3]***

*Award **[1]** for identification of sociocultural issue.*
*Award **[1]** each for any two valid points related to the chosen sociocultural issue.*
*Do not accept contraception for condom use.*
*Apply / OWTTE throughout.*
*Allow other acceptable alternatives.*

**D4.** (a) viruses smaller than bacteria;
viruses do not have a nucleus/cytoplasm/cell membrane/cell wall/ribosomes;
viruses are not cells;
viruses do not feed/excrete/grow; ***[1 max]***

(b) overuse of antibiotics has increased proportion of resistant bacteria;
use of penicillin in animal feedstock has introduced antibiotics into human food chain (increasing proportion of resistant bacteria);
patients not completing course of antibiotics increases proportion/spread of resistant bacteria; ***[3]***

**Option E — Environmental chemistry**

**E1.** (a) CO;
NO;
*Accept $NO_x$ / $NO_2$.*
VOCs/volatile organic compounds / unburned hydrocarbons;
particulates / carbon; ***[3 max]***
*Accept names.*

(b) $2CO + 2NO \rightarrow 2CO_2 + N_2$ / $CO + NO \rightarrow CO_2 + \frac{1}{2}N_2$ / $2CO + O_2 \rightarrow 2CO_2$ / $CO + \frac{1}{2}O_2 \rightarrow CO_2$; ***[1]***
*Ignore state symbols.*

(c)

| Pollutant | Effect |
|---|---|
| *Carbon dioxide* | *Contributes to global warming* |
| *CO* | toxic / prevents haemoglobin from transporting oxygen; |
| *$NO_x$* | toxic / smog / acid deposition/rain; |
| *VOCs* | smog / forms (toxic) PANs/peroxyacylnitrates; |
| *Particulates* | smog / respiratory problems / lung diseases / carcinogenic/cancer-causing; |

*More specific lung diseases may be given e.g. emphysema, bronchitis etc.*

**E2.** *Source*:
power stations / (cooling processes in) industry/factory;

*Effect*:
lowers oxygen solubility / *OWTTE*;

*Result*:
less oxygen for fish / fish harmed/die; ***[3]***
*Accept increased need for oxygen because of increased metabolism.*

**E3.** (a) (i) substances that plants need for growth; ***[1]***

(ii) harvesting of crops (removes nutrients);
(nutrients replaced by) compost/(artificial) fertilizer; ***[2]***
*Accept loss of nutrients through irrigation/soil loss/acidification through addition of fertilizer.*

(b) soil organic matter/SOM;

*Explanation:* ***[1 max]***
improves structural stability;
influences water retention;
alters soil thermal properties; ***[2]***

**E4.** (a) highly radioactive; ***[1]***

(b) (i) landfill not advisable because radioactivity can leach/escape/leak (from rain water) / *OWTTE*;
incineration spreads radioactivity / *OWTTE*; ***[2]***

(ii) glasification / synroc / vitrification;
locks up radioactivity for the long term;

**OR**

ion exchange;
concentrates radioactive material for further treatment;

**OR**

transmutation;
waste is turned into safer isotopes; ***[2]***

**Option F — Food chemistry**

**F1.** (a) (incorrect) water content
chemical/pH change
light
temperature
contact with air/oxygen
bacterial/fungal degradation / microbial spoilage ***[2 max]***
*Award **[2]** for four correct, award **[1]** for three or two correct.*

(b) disagreeable flavour(s)/smell/odour/taste;
due to breakdown/oxidation of fats (in air); ***[2]***

**F2.** (a) *Dye*:
synthetic (water-soluble) colourant;

*Pigment*:
naturally occurring colourant; ***[2]***

(b) (i) red/orange/yellow absorbed;
blue/complementary colour reflected/transmitted; ***[2]***
*Award **[1 max]** for all colours other than blue absorbed.*

(ii) strawberries;
raspberries;
cranberries;
bilberries;
chokeberries;
blackberries;
blackcurrants;
cherries;
(red) plums;
(red) grapes; ***[2 max]***
*Accept other correct answers, but do not accept answers which are not fruits (e.g. beetroot, red-cabbage, flowers etc.).*

(iii) low pH **and** low temperature; ***[1]***

**F3.** (a) (i) contains –OH groups;
condensation / esterification; ***[2]***

(ii) contains –OH groups; ***[1]***

(b) to give olestra properties/melting point similar to those of cooking fats / if they were not smaller then olestra would have much higher melting point/very different properties than other cooking fats/*OWTTE*; ***[1]***

**F4.** (a) food derived/produced from a GM organism; ***[1]***

(b) *Benefits **[3 max]***:

*Crops:*
enhanced taste/quality/appearance;
reduced maturation time;
increase in nutrients/yield;
improved resistance to disease/pests/herbicides;
enrichment of rice with vitamin A;

*Animals:*
increased resistance;
increased productivity/feed efficiency;
better yield of milk/egg;
improved animal health;

*Environment:*
"friendly" bio-herbicides/bio-insecticides;
conservation of soil/water/energy;
improved natural waste management;

*Concerns **[1 max]***:
increased allergies;
risk of changing composition of balanced diet;
risk of GM genes (*e.g.* herbicide resistance) escaping to inappropriate areas of agriculture; ***[4 max]***

**Option G — Further organic chemistry**

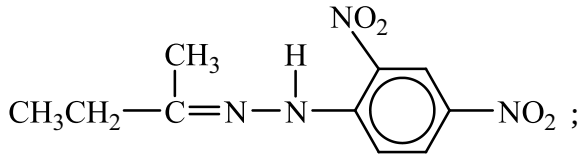
**G1.** (a) hexagonal / ring of six carbon atoms (each with one hydrogen);
planar;
all carbon-carbon bond lengths equivalent / all carbon-carbon bond lengths intermediate between single and double bonds / carbon-carbon bond order of 1.5;
all C–C–C bond angles 120°;
*Allow $sp^2$ (hybridization for C's).*

delocalization / resonance; ***[3 max]***

(b) enthalpy change of hydrogenation not equal to three times enthalpy change of hydrogenation of cyclohexene;
electron density map (of benzene) showing equal electron density/all carbon-carbon bond lengths equivalent / *OWTTE*;
*Allow diffraction pattern or contour map for electron density map.*

only one isomer exists for 1,2-disubstituted benzene compounds / only three disubstituted benzene compounds (rather than four);
undergoes (electrophilic) substitution reactions / does not undergo addition reactions / does not decolorize bromine water; ***[2 max]***

**G2.** (a) **A**: $CH_3CH_2CH(CH_3)Br$; ***[1]***

(b) **B**:  ; ***[1]***

**G3.** (a) (addition of) Mg/magnesium;
$CH_3CH_2CH_2MgBr$;
(addition of) $CO_2$/carbon dioxide **and** $H_2O$/water;
$CH_3CH_2CH_2CO_2H$ / $CH_3CH_2CH_2COOH$; ***[4]***

(b) <u>concentrated</u> phosphoric acid/ $H_3PO_4$/sulfuric acid/ $H_2SO_4$;
$(CH_3)CH=CH_2$;
$Br_2$/bromine;
$BrCH_2CHBrCH_3$; ***[4]***

**G4.** (a) phenol;
negative charge/lone pair on oxygen can interact with delocalized electrons of benzene/aromatic ring so spreads out charge more / *OWTTE*; ***[2]***

(b) chloroethanoic acid;
chlorine (atoms) withdraws electrons from OH bond, making it break more easily to release $H^+$ ions / electron-withdrawing nature of chlorine / greater electronegativity of chlorine / *OWTTE*;
$ClCH_2CO_2^-$ more stable than $CH_3CO_2^-$ because negative charge spread more / *OWTTE*; ***[3]***