M09/4/CHEMI/SP2/ENG/TZ2/XX/M+

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MARKSCHEME

May 2009

CHEMISTRY

Standard Level

Paper 2

14 pages

Subject Details: Chemistry SL Paper 2 Markscheme

Mark Allocation
Candidates are required to answer **ALL** questions in Section A **[30 marks]** and **ONE** question in Section B **[20 marks]**. Maximum total = **[50 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 sheet.

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.

SECTION A

1. (a) carboxylic acid / carboxyl;
ester;
Do not allow carbonyl / acid / ethanoate / formula(–COOH).

aryl group / benzene ring / phenyl; ***[3]***

(b) (i) $M_r(C_7H_6O_3) = 138.13$;

$n = \left(\frac{3.15}{138.13} =\right) 2.28 \times 10^{-2}\,(\text{mol})$; ***[2]***

*Award **[2]** for the correct final answer.*

(ii) $M_r(C_9H_8O_4) = 180.17$;

$m = (180.17 \times 2.28 \times 10^{-2} =) 4.11\,(\text{g})$; ***[2]***

Accept range 4.10–4.14
*Award **[2]** for the correct final answer.*

(iii) $\left(\text{percentage yield } = \frac{2.50}{4.11} \times 100 =\right) 60.8\,\%$; ***[1]***

Accept 60–61%.

(iv) 3;

$\left(\text{percentage uncertainty } = \frac{0.02}{2.50} \times 100 =\right) 0.80\,\%$; ***[2]***

Allow 0.8%

(v) sample contaminated with ethanoic acid / aspirin not dry / impure sample; ***[1]***
Accept specific example of a systematic error.
Do not accept error in reading balance/weighing scale.
Do not accept yield greater than 100%.

(vi) hypothesis not valid/incorrect;

Accept any of the following for the second mark
C–O and C=O bond lengths will be different;
C2–O3 bond is longer than C8–O4 bond;
C8–O4 bond shorter than C2–O3 bond;
a CO single bond is longer than a CO double bond; ***[2 max]***
Accept C8–O4 is a double bond hence shorter.

(vii) *Brønsted-Lowry definition of an acid*
proton/H^+/hydrogen ion donor;

Conjugate base of CH_3COOH
$CH_3COO^-/CH_3CO_2^-$; ***[2]***
Do not accept $C_2H_3O_2^-$ */ethanoate.*

2. (a) Na, Mg: basic;
Al: amphoteric;
Do not accept amphiprotic.

Si to Cl: acidic; ***[3]***
*Award **[1]** for stating oxides become more basic towards left/Na and more acidic towards right/Cl.*
Do not penalize incorrect formulas of oxides.

(b) NO_2/nitrogen dioxide / N_2O_4/dinitrogen tetroxide / SO_2/sulfur dioxide / SO_3/sulfur trioxide; ***[1]***
Do not accept NO/NOx/CO_2/CO.

(c) measure electrical conductivity;
strong acids are good conductors/better conductors than weak acids / weak acids are poor conductors;

OR

react with magnesium or a named active metal/metal carbonate/hydrogen carbonate/bicarbonate;
Do not accept Na/K

strong acids react faster/more gas bubbles (per unit time)/more heat produced / weak acids react slower/less gas bubbles (per unit time)/less heat produced; ***[2 max]***
Do not accept answers based on titration curves as they are based on pH.
Accept Neutralization: weak acid would produce less energy/less temperature increase compared to a strong acid.

3.

C	N	O	H	
$\frac{20.2}{12.01}$	$\frac{11.4}{14.01}$	$\frac{65.9}{16.00}$	$\frac{2.50}{1.01}$	
$= 1.68$	$= 0.814$	$= 4.12$	$= 2.48$	;
$\frac{1.68}{0.814} = 2$	$\frac{0.814}{0.814} = 1$	$\frac{4.12}{0.814} = 5$	$\frac{2.48}{0.814} = 3$	;

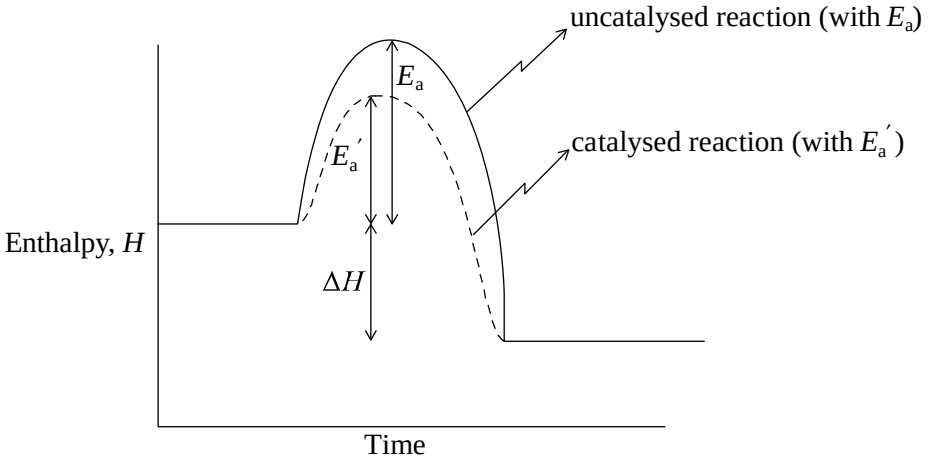
$C_2NO_5H_3$; ***[3]***

No penalty for use of 12, 1 and/or 14.
*Award **[1 max]** if the empirical formula is correct, but no working shown.*

4. (a) (minimum) energy needed for a reaction to occur / (minimum) energy difference between reactants and transition state; ***[1]***

(b) particles must collide;
appropriate collision geometry/orientation;
$E \geq E_a$; ***[2 max]***

(c) *Diagram showing*:
correct labelling of axes (enthalpy/H/(potential) energy for *y*-axis and time/progress/course of reaction/reaction coordinate for *x*-axis) **and** H (products) line shown below H (reactants) line;
correct labelling of the two curves, catalysed and uncatalysed;
correct position of E_a shown with lines for a catalysed and uncatalysed reaction;
the correct label ΔH /change in enthalpy; ***[3max]***
Do not penalize if reactants and products are not labelled.



*If an endothermic reaction is shown, award **[2 max]** if all other parts are shown correctly.*

SECTION B

5. (a) (i) $(K_c =) [SO_3]^2 / [O_2][SO_2]^2$; ***[1]***

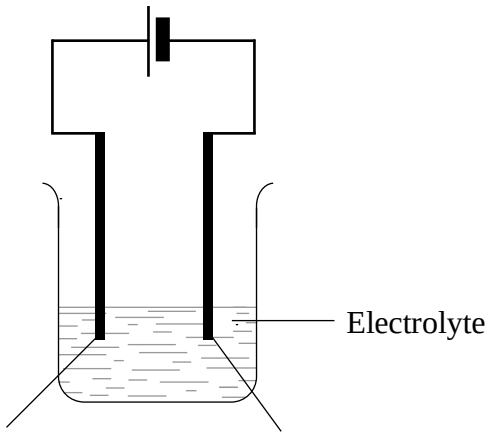
(ii) yield (of SO_3) decreases;
forward reaction is exothermic / reverse/backwards reaction is endothermic / equilibrium shifts to absorb (some of) the heat; ***[2]***
Do not accept exothermic reaction or Le Châtelier's Principle.
Do not allow ECF.

(iii) no effect; ***[1]***

(iv) no effect;
the rates of both the forward and reverse reactions increase equally; ***[2]***

(b) (i) increase in the oxidation number; ***[1]***

(ii) *Annotated diagram of cell showing*:
power supply/battery;
electrolyte;
cathode/negative electrode **and** anode/positive electrode; ***[3]***



(iii) (solid) ions in a lattice / ions cannot move;
(molten) ions mobile / ions free to move; ***[2]***

(iv) reduction occurs at the cathode/negative electrode **and** oxidation occurs at the anode/positive electrode;
Cathode/negative electrode: $Na^+ + e^- \rightarrow Na$;
Anode/positive electrode: $2Cl^- \rightarrow Cl_2 + 2e^-$ / $Cl^- \rightarrow \frac{1}{2}Cl_2 + e^-$;
*Award **[1 max]** if the two electrodes are not labelled/labelled incorrectly for the two half-equations.*

Overall cell reaction: $Na^+(1) + Cl^-(1) \rightarrow Na(1) + \frac{1}{2}Cl_2(g)$ ***[5]***
*Award **[1]** for correct equation and **[1]** for correct state symbols.*
Allow NaCl (l) instead of Na^+(l) and Cl^-(l).

(v) Al does not corrode/rust / Al is less dense/better conductor/more malleable; ***[1]***
Accept Al is a lighter (metal compared to Fe).
Accept converse argument.

(vi) electrolytic cell converts electrical energy to chemical energy **and** voltaic cell converts chemical energy to electrical energy / electrolytic cell uses electricity to carry out a (redox) chemical reaction **and** voltaic cell uses a (redox) chemical reaction to produce electricity / electrolytic cell requires a power supply **and** voltaic cell does not;

electrolytic cell involves a non-spontaneous (redox) reaction **and** voltaic cell involves a spontaneous (redox) reaction;

in an electrolytic cell, cathode is negative and anode is positive **and** *vice-versa* for a voltaic cell / electrolytic cell, anode is positive and voltaic cell, anode is negative / electrolytic cell, cathode is negative and voltaic cell, cathode is positive;

voltaic cell has two separate solutions **and** electrolytic cell has one solution / voltaic cell has salt bridge and electrolytic cell has no salt bridge;

electrolytic cell, oxidation occurs at the positive electrode/anode **and** voltaic cell, oxidation occurs at the negative electrode/anode and *vice-versa*; ***[2 max]***

6. (a) (i) energy required to break (1 mol of) a bond in a gaseous molecule/state;
Accept energy released when (1 mol of) a bond is formed in a gaseous molecule/state / enthalpy change when (1 mol of) bonds are made or broken in the gaseous molecule/state.

average values obtained from a number of similar bonds/compounds / *OWTTE*; ***[2]***

(ii) *Bonds broken*
(1)(C–C) + (1)(O–H) + (5)(C–H) + (1)(C–O) + (3)(O=O)
$= (1)(347) + (1)(464) + (5)(413) + (1)(358) + (3)(498) = 4728\,(\text{kJ})$;
Bonds formed
$(2\times 2)\,(\text{C=O}) + (3\times 2)\,(\text{O–H})$
$= (4)(746) + (6)(464) = 5768\,(\text{kJ})$;
$\Delta H = 4728 - 5768 = -1040\,\text{kJ mol}^{-1}$ / $-1040\,\text{kJ}$; ***[3]***
Units needed for last mark.
*Award **[3]** for final correct answer.*
*Award **[2]** for +1040 kJ.*

(iii) $M_r(C_2H_5OH) = 46.08 / 46.1$ **and** $M_r(C_8H_{18}) = 114.26 / 114.3$;
1 g ethanol produces 22.57 kJ **and** 1 g octane produces 47.88 kJ; ***[2]***
Accept values ranges of 22.5–23 and 47.8–48 kJ respectively.
No penalty for use of $M_r = 46$ and $M_r = 114$.

(iv) **A**: CH_3CHO;
B: CH_3COOH/CH_3CO_2H;
Accept either full or condensed structural formulas but not the names or molecular formulas.

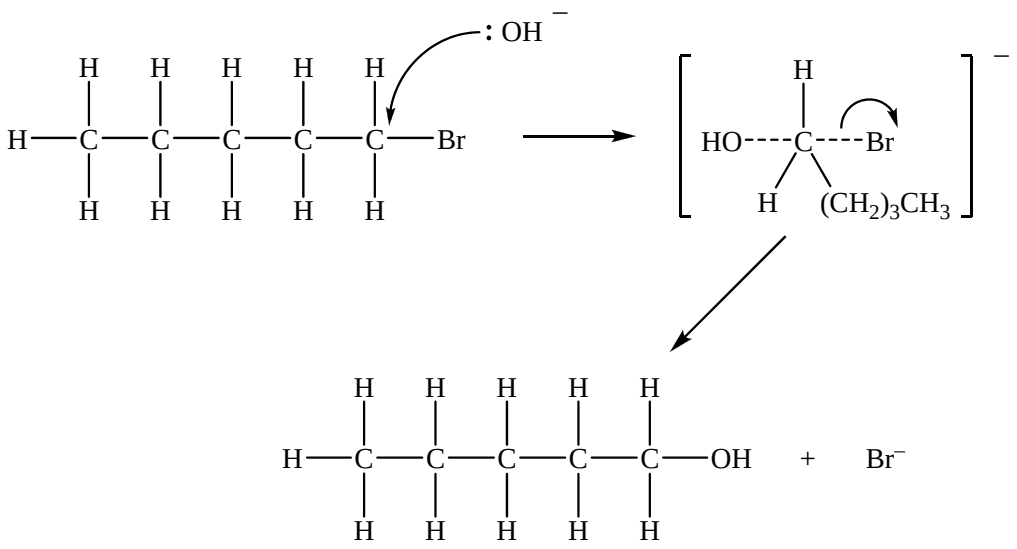
A: distillation;
B: reflux; ***[4]***

(v) ethanol/ CH_3CH_2OH;
hydrogen bonding (in ethanol); ***[2]***
Award second point only if the first is obtained.

(vi) (concentrated) H_3PO_4 /(concentrated) phosphoric acid / H_2SO_4 /sulfuric acid;
dyes / drugs / cosmetics / solvent / (used to make) esters / (used in) esterification/disinfectant; ***[2]***

(b) (i) (2-)methylbutane / (2,2-)dimethylpropane; ***[1]***

(ii)



curly arrow going from O/lone pair of OH^- (but not H) to the C attached to Br;
leaving of Br;
transition state representation with both Br and OH attached to C–1;
correct products $CH_3(CH_2)_4OH$ **and** Br^-; ***[4]***

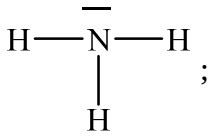
Charge must be shown for TS.
C–OH and C–Br bonds in TS must be represented by dashed lines.

7. (a) (i) atoms of the same element with the same atomic number/*Z*/same number of protons, but different mass numbers/*A*/different number of neutrons; ***[1]***

(ii) $(0.9223\times 28) + (0.0468\times 29) + (0.0309\times 30)$;
28.1/28.11; ***[2]***
*Working must be shown to get **[2]**, do not accept 28.09 on its own (given in the data booklet).*

(iii) *Silicon dioxide*
<u>single</u> covalent (bonds);
network/giant covalent/ macromolecular / repeating tetrahedral units;

Carbon dioxide
<u>double</u> covalent (bonds);
(simple / discrete) molecular; ***[4]***
Marks may be obtained from suitable structural representations of SiO_2 and CO_2.

(b) (i)  ;
Allow crosses or dots for lone-pair.

trigonal/triangular pyramidal;
(~)107° / less than 109.5°;
Do not allow ECF.

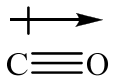
LP-BP repulsion > BP-BP repulsion / one lone pair and three bond pairs / lone pairs/non-bonding pairs repel more than bonding-pairs; ***[4]***
Do not accept repulsion between atoms.

(ii) boiling points increase going down the group (from PH_3 to AsH_3 to SbH_3);
M_r/number of electrons/molecular size increases down the group;
Accept electron cloud increases down the group for the second marking point.

greater dispersion/London/van der Waal's forces;

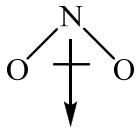
NH_3/ammonia has a higher boiling point than expected due to the <u>hydrogen bonding between</u> the molecules; ***[4]***
Do not accept hydrogen bonding alone.

(c) *CO*:



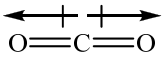
*Award **[1]** for showing the net dipole moment, or explaining it in words (unsymmetrical distribution of charge).*

NO_2 :



*Award **[1]** for correct representation of the bent shape **and [1]** for showing the net dipole moment, or explaining it in words (unsymmetrical distribution of charge).*

CO_2 :



*Award **[1]** for correct representation of the linear shape **and [1]** for showing the two equal but opposite dipoles or explaining it in words (symmetrical distribution of charge).* ***[5]***

For all three molecules, allow either arrow or arrow with bar for representation of dipole moment.
Allow correct partial charges instead of the representation of the vector dipole moment.
Ignore incorrect bonds.
Lone pairs not needed.