M14/4/CHEMI/SP2/ENG/TZ2/XX/M

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MARKSCHEME

May 2014

CHEMISTRY

Standard Level

Paper 2

12 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.

2. Each marking point has a separate line and the end is shown 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 ***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. When marking, indicate this by adding **ECF** (error carried forward) on the script.

10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme, similarly, if the formula is specifically asked for, unless directed otherwise in the markscheme do not award a mark for a correct name.

12. 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.

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

SECTION A

1. (a) $M(CH_3COOH)\left(=(4\times1.01)+(2\times12.01)+(2\times16.00)\right)=60.06\,(g\,mol^{-1})$;
Accept 60 (g mol^{-1}).
mass $(CH_3COOH)(=5.00\times1.05)=5.25\,(g)$;
$\frac{5.25}{60.06}=0.0874\,(mol)$; ***[3]***
*Award **[3]** for correct final answer.*
Accept 0.0875 (comes from using Mr = 60 g mol^{-1}).

(b) catalyst / *OWTTE*; ***[1]***

(c) hydrochloric acid/HCl; ***[1]***

(d) (i) $\pm0.1\,/\,0.10\,(cm^3)$; ***[1]***
*Do **not** accept without ±.*

(ii) $26.00\,(cm^3)$; ***[1]***

(iii) $0.200\times\frac{23.00}{1000}=0.0046$;
$0.0046\times\frac{50.0}{5.00}=0.0460\,(mol)$; ***[2]***

(e) $\frac{0.0874-0.0460}{0.0874}\times100=47.4\%$; ***[1]***

(f) $(K_c=)\frac{[CH_3COOC_2H_3][H_2O]}{[C_2H_5OH][CH_3COOH]}$; ***[1]***
Do not penalize minor errors in formulas.
Accept $(K_c=)\frac{[ester][water]}{[ethanol\,/\,alcohol][(ethanoic)\,acid]}$.

(g) repeat the titration a day/week later (and result should be the same) / *OWTTE*; ***[1]***
Accept "concentrations/physical properties/macroscopic properties of the system do not change".

(h) enthalpy change/ΔH for the reaction is (very) small / *OWTTE*; ***[1]***

(i) decreases (the amount of ethanoic acid converted);
Accept "increases amount of ethanoic acid present <u>at equilibrium</u>" / OWTTE.
(adding product) shifts position of equilibrium towards reactants/LHS / increases the rate of the reverse reaction / *OWTTE*; ***[2]***

(j) ethyl ethanoate/$CH_3COOC_2H_5$;
forms only weak hydrogen bonds (to water); ***[2]***
Allow "does not hydrogen bond to water" / "hydrocarbon sections too long" / OWTTE.
M2 can only be given only if M1 correct.

(k) (large excess of) water will shift the position of equilibrium (far to the left) / *OWTTE*; ***[1]***
Accept any other chemically sound response, such as "dissociation of ethanoic acid would affect equilibrium".

2. (a)

	Protons	Neutrons	Electrons
$^{11}_{5}B$	5	6	5

; ***[1]***

(b) $10x + 11(100 - x) = 10.8 \times 100$;
$(x =) 20\%$; ***[2]***
*Award **[2]** for correct final answer.*
Do not allow ECF.

(c) radioactive/radioisotope(s)/give out radiation; ***[1]***
Accept answers that outline the effects of radioactive pollution of the environment.
Do not accept "unstable".

(d) (i) BF_3; ***[1]***

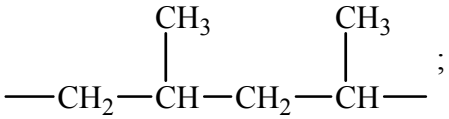
(ii) incomplete valence shell / electron deficient / *OWTTE*;
capable of accepting an electron pair; ***[2]***

3. (a) $C_9H_{20}(l) + 14O_2(g) \rightarrow 9CO_2(g) + 10H_2O(l)$
correct reactants and products;
Do not penalize if heat given on RHS of eqn.

correct coefficients; ***[2]***
Ignore state symbols.
No ECF if reactants and products incorrect.

(b) insufficient oxygen present / *OWTTE*; ***[1]***
Allow "air" instead of "oxygen".
Do not accept "incomplete combustion".

(c) (i) addition (polymerization); ***[1]***

(ii) 
; ***[1]***
Methyl groups must be on alternate carbons but accept other orientations.
Extension bonds required for the mark.
Allow mark if three repeating units (6 C–atoms in chain) given.

SECTION B

4. (a) (i) from (pale) green/colourless to yellow/orange/brown; ***[1]***
Initial colour must be stated.
*Do **not** accept "clear/transparent" instead of "colourless".*

(ii) chlorine more reactive/more powerful oxidizing agent (than bromine);
Accept opposite statements for bromine.
Accept "chloride ion a weaker reducing agent" / "bromide ion a stronger reducing agent".
Accept "chlorine more electronegative than bromine".

$Cl_2(aq) + 2NaBr(aq) \rightarrow Br_2(aq) + 2NaCl(aq)$ /
$Cl_2(aq) + 2Br^-(aq) \rightarrow Br_2(aq) + 2Cl^-(aq)$; ***[2]***
Ignore state symbols.
*Do **not** accept with equilibrium sign.*

(b) solid (in a colourless solution); ***[1]***
Accept "dark brown solution".

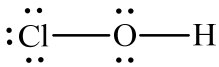
(c) (i) chloric(I) acid (shown as) a molecule/molecular, but hydrochloric acid (shown as being) split into ions / *OWTTE*; ***[1]***
Accept "chloric(I) acid is partially dissociated and hydrochloric acid is fully dissociated".
Reference needed to both acids for mark.

(ii) $HOCl(aq) \rightleftharpoons H^+(aq) + ClO^-(aq)$ / $HOCl(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + ClO^-(aq)$; ***[1]***
Equilibrium sign required for the mark.
Ignore state symbols.

(iii) acid displaces the equilibrium to the left (to form chlorine);
chlorine is toxic/poisonous/harmful/lung irritant; ***[2]***
Accept answers that refer to the (c) (ii) equilibrium.

(iv) chloric(I) acid has –OH group / hydrogen attached to a very electronegative atom;
Accept polar molecule.

can form hydrogen bonds <u>to water</u>;
hydrogen bonding to water increases its solubility;
(as a weak acid it is) in equilibrium with ions; ***[2 max]***

(v)  ; ***[1]***
Accept lines, dots or crosses to represent electron pairs.

(vi) $\sim 104^\circ$;
Accept values between 102° and 106°.

four electron pairs/regions of high electron density around O atom / electron pairs/regions of high electron density tetrahedrally arranged and two lone/non-bonding electron pairs on O atom;
Accept Lewis structure with two lone pairs on O and two angular bond pairs if given here as equivalent to M2.

lone pair–bonding pair repulsion greater than bonding pair–bonding pair repulsion; ***[3]***

(d) (i) (l) $ClO^- + \mathbf{2}\ H^+ + \mathbf{2}\ e^- \rightleftharpoons$ (l) H_2O + (l) Cl^-;
(l) $SO_4^{2-} + \mathbf{4}\ H^+ + \mathbf{2}\ e^- \rightleftharpoons$ (l) $SO_2 + \mathbf{2}\ H_2O$; ***[2]***

(ii) *Award **[2]** for all correct, **[1]** for 2 or 3 correct.*

Element	Initial oxidation number	Final oxidation number
Chlorine	+I / +1;	–I / –1;
Sulfur	+VI / +6;	+IV / +4;

[2]

Remember to apply ECF from previous equations.
*Penalise incorrect notation (eg, 4 or 4+ rather than +4) once only, so award **[1]** for a fully correct answer in an incorrect format.*

(iii) $ClO^-(aq) + SO_2(aq) + H_2O(l) \rightleftharpoons SO_4^{2-}(aq) + 2H^+(aq) + Cl^-(aq)$
correct reactants and products;
balancing and cancelling e^-, H^+ and H_2O; ***[2]***
Ignore state symbols.
Do not penalize equilibrium sign.

5. (a) $\text{mol } Na_2S_2O_3 (= 2.50 \times 0.0200) = 0.0500$;

$M_r Na_2S_2O_3 \bullet 5H_2O \left(= (2 \times 22.99) + (2 \times 32.06) + (3 \times 16.00) + (5 \times 18.02)\right) = 248.20$;

Allow 248.

mass $Na_2S_2O_3 \bullet 5H_2O = (0.0500 \times 248.20) = 12.4\,\text{g}$; ***[3]***

*Award **[3]** for correct final answer.*
*Award **[2]** for 7.91g (water of crystallization omitted in M_r calculation).*

(b) (i)

Liquid	$0.500\,\text{mol dm}^{-3}$ HCl	$0.0200\,\text{mol dm}^{-3}$ $Na_2S_2O_3$	Water
Volume / cm^3	10.0	20.0	20.0

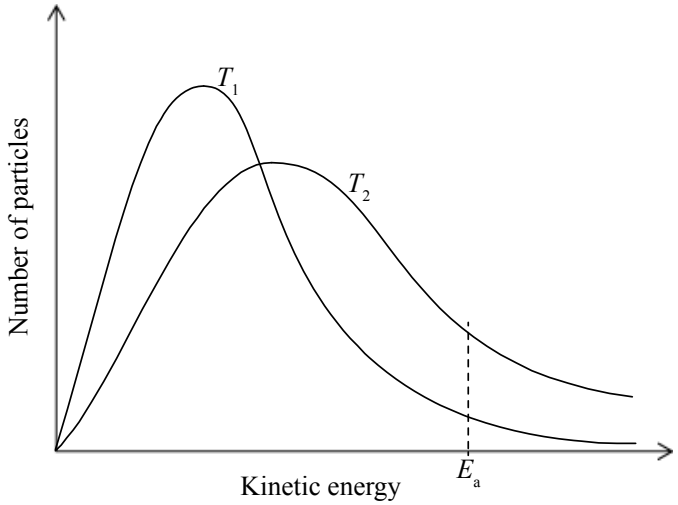
; ***[1]***

Accept other volumes in a 1:2:2 ratio.

(ii) depth of liquid in the beaker must remain constant / *OWTTE*; ***[1]***
Accept "same thickness of glass" and any other valid point, such as answers framed around minimizing uncontrolled variables / making it a "fair test".

(iii) increases the time;
decrease in collision frequency/number of collisions per unit time; ***[2]***
Do not award mark for decrease in number of collisions.

(c) (i)



labelled y-axis: number of particles / probability of particles (with that kinetic energy) **and** *labelled x-axis:* (kinetic) energy;
Allow fraction/proportion/amount of particles (with kinetic energy) for y-axis label.
Allow speed/velocity for x-axis label.

T_2 curve broader **and** with maximum lower **and** to right of T_1 curve;
Do not award this mark if both curves not asymmetric.
Curves must pass through the origin and be asymptotic to x axis.
Do not award this mark if curves not labelled.

E_a marked on graph; ***[3]***

(ii) kinetic energy of molecules increases;
This may be answered implicitly in the final marking point.

frequency of collision/number of collisions per unit time increases;
Only penalize use of "number of collisions" if not penalized in (b)(iii).

greater proportion of molecules have energy greater than/equal to activation energy / rate related to temperature by the Arrhenius equation; ***[3]***
*Award **[1 max]** for statements such as "there will be more successful collisions" if neither of last two marking points awarded.*

(d) (i) $[H^+] = 0.5 \times \frac{10}{50} = 0.1 (\text{mol dm}^{-3})$;
$\text{pH} (= -\log[H^+] = -\log(0.10)) = 1$; ***[2]***

(ii) 90 %; ***[1]***

(e) (i) $\text{mol } Na_2S_2O_3 = \text{mol } SO_2 = 0.0400 \times 0.0200 = 0.000800$;
$V = \frac{n \times R \times T}{P} / \frac{0.000800 \times 8.31 \times 300}{10^5}$;
$(1.99 \times 10^{-5} \text{m}^3) = 19.9 (\text{cm}^3)$;
*Award **[3]** for correct final answer.*
Accept 20.0 cm^3 if R =8.314 is used.
*Award **[2]** for 17.9 cm^3 or 19.2 cm^3 (result from using molar volume at standard temperature and pressure or at room temperature and pressure).*

OR

$\text{mol } Na_2S_2O_3 = \text{mol } SO_2 = 0.0400 \times 0.0200 = 0.000800$;
$V = 0.00080 \times 2.24 \times 10^{-2} \times \left[\frac{1.00 \times 10^5}{1.01 \times 10^5} \right] \times \frac{300}{273}$;
$(1.95 \times 10^{-5} \text{ m}^3) = 19.5 (\text{cm}^3)$; ***[3]***
*Award **[3]** for correct final answer.*
*Deduct **[1]** for answers based on amount of HCl, so correct calculation would score **[2 max]**.*

(ii) sulfur dioxide is soluble in water; ***[1]***
Accept other reasonable responses based on sound chemistry.
Accept "syringe more accurate/precise" or "less gas escapes".

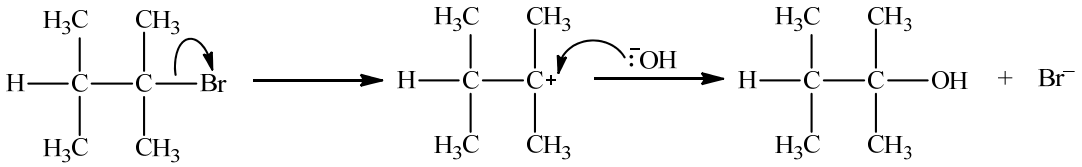
6. (a) 2,3-dimethylbut-2-ene; ***[1]***
Ignore punctuation.

(b) hydrogen bromide / hydrobromic acid / HBr; ***[1]***

(c) (i) ultraviolet light/sunlight; ***[1]***
Accept "very high temperature".

(ii) random/further/multiple substitution (so low probability of desired product) / would give a mixture of many different products / *OWTTE*; ***[1]***

(d) (i) (aqueous) sodium hydroxide/NaOH / potassium hydroxide/KOH; ***[1]***
Accept hydroxide ion/OH^-.

(ii) 

S_N1:
curly arrow from C – Br bond showing Br leaving;
representation of tertiary carbocation;
curly arrow going from lone pair/negative charge on O in HO^- to C^+; ***[3]***
Do not allow arrow originating on H in HO^-.
*Award **[2]** for perfect S_N2 mechanism.*
*Award **[1]** for S_N2 mechanism with minor mistakes.*

(e) water / steam; ***[2]***
heat and acid catalyst /*(concentrated)* H_2SO_4/H_3PO_4;

(f) (i) (it is a) tertiary/3^o alcohol / carbon of C–OH is not bonded to a hydrogen; ***[1]***
Accept "it is not a primary or secondary alcohol".

(ii) any $C_6H_{14}O$ primary alcohol / $C_5H_{11}CH_2OH$; ***[1]***

(g) (i) Ni/Pt/Pd catalyst; ***[1]***

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

(iii) *bonds broken:* $\left(\text{E(C=C)} + \text{E(H–H)} = 612 + 436 =\right) 1048\,(\text{kJ mol}^{-1})$;
Accept (6956 + 436 =) 7392 if all bonds in alkene broken.

bonds formed: $\text{E(C–C)} + 2 \times \text{E(C–H)} = 347 + (2 \times 413) = 1173\,(\text{kJ mol}^{-1})$;
Accept 7517 if all the bonds in the product are summed.

$\Delta H = 1048 - 1173 \,/\, 7392 - 7517 = -125\,(\text{kJ mol}^{-1})$;
*Award **[3]** for correct final answer.*
*Award **[2]** for +125.*

exothermic; ***[4]***
Apply ECF if sign of ΔH incorrect.
Do not award a mark for "exothermic" if ΔH given as positive.

(iv) energy required to heat water $\left(= m \times s \times \Delta T = 1 \times 4.18 \times (100 - 20)\right) = 334.4\,(\text{kJ})$;
Ignore sign of energy change.

amount required $= \dfrac{334.4}{4000} = 0.0836\,(\text{mol})$; ***[2]***
*Award **[2]** for correct final answer.*