M14/4/CHEMI/SP2/ENG/TZ1/XX/M

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

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.

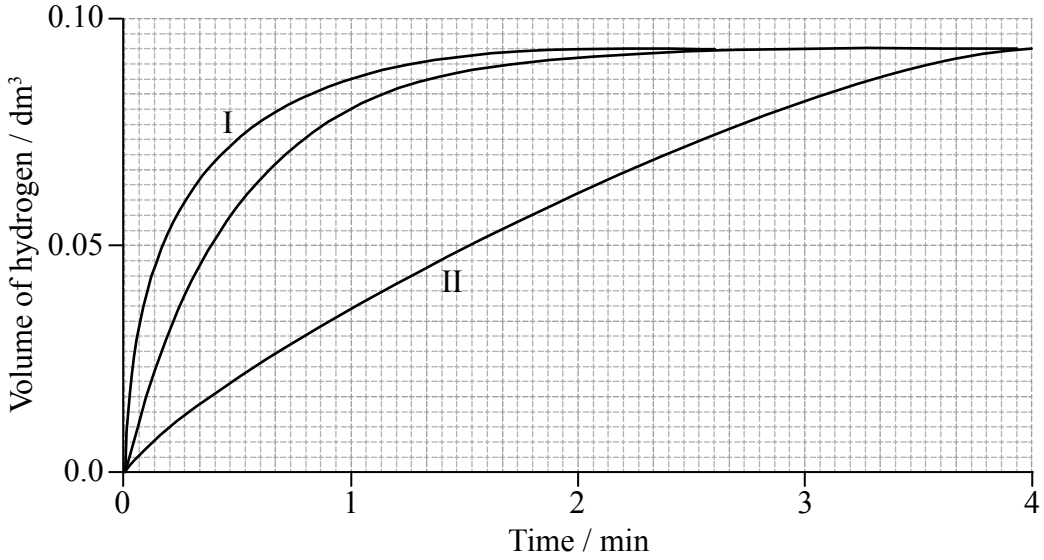
11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme, similarly, if the formula is specifically asked for, unless directed otherwise in the markscheme do not award a mark for a correct name.

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) (i)



I: line which is steeper/increases faster **and** finishes at the same height;
II: line which is less steep/increases more slowly **and** finishes at the same height; ***[2]***

(ii) mass of hydrogen produced is very small (so not accurate) / decrease in mass is very small (so not accurate); ***[1]***

(b) (i) $n(\mathrm{MgSO_4}) = \left(\frac{3.01}{120.37} =\right) 0.0250\,(\mathrm{mol})$; ***[1]***

(ii) energy released $= 50.0 \times 4.18 \times 9.7 = 2027\,(\mathrm{J}) / 2.027\,(\mathrm{kJ})$;
$\Delta H_1 = -81\,(\mathrm{kJ\,mol^{-1}})$; ***[2]***

*Award **[2]** for correct answer.*
*Award **[2]** if 53.01 is used giving an answer of –86 (kJ mol^{-1}).*
*Award **[1 max]** for +81/81/+86/86 (kJ mol^{-1}).*
*Award **[1 max]** for –81000/–86000 if units are stated as J mol^{-1}.*
Allow answers to 3 significant figures.

(c) (i) $\Delta H\,(= \Delta H_1 - \Delta H_2) = -99\,(\mathrm{kJ\,mol^{-1}})$; ***[1]***

*Award **[1]** if –86 is used giving an answer of –104 (kJ mol^{-1}).*

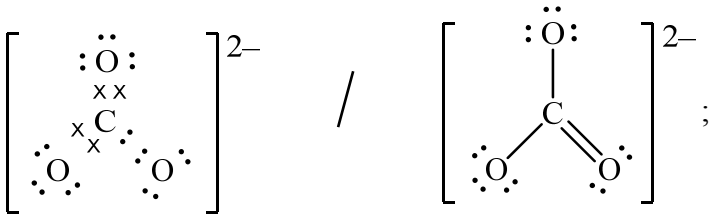
(ii) $\frac{(103-99)}{103} \times 100 = 3.9\%$; ***[1]***

Accept answer of 2.9% if –100 used.
*Award **[1]** if –104 is used giving an answer of 1.0% .*
Accept correct answers which are not to 1 decimal place.

(d) $MgSO_4$ not completely anhydrous / *OWTTE*;
$MgSO_4$ is impure;
heat loss to the atmosphere/surroundings;
specific heat capacity of solution is taken as that of pure water;
experiment was done once only so it is not scientific;
density of solution is taken to be 1 g cm^{-3};
mass of $7H_2O$ ignored in calculation;
uncertainty of thermometer is high so temperature change is unreliable;
literature values determined under standard conditions but this experiment is not;
all solid not dissolved; ***[2 max]***

(e) (i) $H_2SO_4(aq) + MgCO_3(s) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$; ***[1]***

Ignore state symbols.
Do not accept H_2CO_3.

(ii) 

Accept crosses, lines or dots as electron pairs.
Accept any correct resonance structure.
*Award **[0]** if structure is drawn without brackets and charge.*
*Award **[0]** if lone pairs not shown on O atoms.*

shape: trigonal/triangular planar;
bond angle: 120°; ***[3]***

Accept answers trigonal/triangular planar and 120° if M1 incorrect, but no other answer should be given credit.

2. (a) *Q:* creates positive ions/cations / electron is knocked off atom / *OWTTE*;
by bombardment of electrons;

S: ions deflected by an (external) magnetic field;
deflection of ions depends on mass/*m/z* (and charge) / heavier ions are deflected less than lighter ions / more highly charged ions are deflected more than less highly charged ions; ***[4]***
*Award **[1 max]** for simply stating ionization and deflection.*

(b) (i) ratio of average/mean mass of atom to $\frac{1}{12}$ of mass of C–12 (isotope) / average/mean mass of atom on scale where one atom of C–12 has mass of 12 / weighted average/mean mass of isotopes of element compared to $\frac{1}{12}$ of mass of C–12 / *OWTTE*; ***[1]***
Award no mark if "element" is used instead of "atom" in first two alternatives.
Allow "mass of an atom relative to the mass of $\frac{1}{12}$ of C–12".

(ii) $(A_r =) 0.7899 \times 24 + 0.1000 \times 25 + 0.1101 \times 26$;
24.32; ***[2]***
*Award **[2]** for correct final answer.*
*Award **[1 max]** for 24.31 with correct working.*
*Award **[0]** for 24.31 (Data Booklet value) if working is incorrect or no working is shown.*
*Final answer must be to 2 decimal places to score **[2]**.*

3. (a) $(K_c =) \frac{[N_2O_4(g)]}{[NO_2(g)]^2}$; ***[1]***
Ignore state symbols.

(b) (i) equilibrium shifts to left as there are more moles (of gas) on reactant side;
no change to K_c as it is a constant at fixed temperature / *OWTTE*; ***[2]***
*Award **[1 max]** for correct equilibrium shift and Kc change if no explanation given.*

(ii) equilibrium shifts to left since reaction is exothermic/ΔH negative / reverse reaction is endothermic/absorbs heat;
value of K_c decreases because less N_2O_4 and more NO_2 / *OWTTE*; ***[2]***
*Award **[1 max]** for correct equilibrium shitft and Kc change if no explanation given.*

4. (a) butane < propanal < ethanoic acid / $CH_3CH_2CH_2CH_3 < CH_3CH_2CHO < CH_3COOH$; ***[1]***

(b) all three compounds have similar molar masses;
butane non-polar so no attraction to water molecules/insoluble;
propanal polar so can form some interactions with water molecules;
ethanoic acid can form (more) hydrogen bonds with water molecules / *OWTTE*; ***[3 max]***

*Award **[1 max]** for butane is non-polar and propanal and ethanoic acid are both polar.*

SECTION B

5. (a) (i) $2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq) / Na(s) + H_2O(l) \rightarrow \frac{1}{2}H_2(g) + NaOH(aq)$; ***[1]***

Ignore state symbols.

(ii) bubbles/gas produced / crackling / fizzing / *OWTTE*;
temperature (of water) increases;
sodium floats on water / melts into a ball / disappears / *OWTTE*;
sharp smell;
small yellow sparks; ***[2 max]***

(iii) K > Na > Li; ***[1]***

(b) (i) $Br_2(aq)$: no change;
KBr (aq): colour change / from colourless to red/yellow/orange/brown; ***[2]***

(ii) $2Br^-(aq) \rightarrow Br_2(aq) + 2e^-$;
$Cl_2(g) + 2e^- \rightarrow 2Cl^-(aq)$; ***[2]***

Ignore state symbols.
Accept e instead of e^-.

(c) (i) HF has hydrogen bonds (between molecules); ***[1]***

(ii) strength of van der Waals'/London/dispersion forces increases;
as mass/size/number of electrons of halogen atom/molecule increases; ***[2]***

(d) Cl^- has an extra electron so extra repulsions push electrons farther apart / Cl^- and Cl have same number of occupied electron shells **and** Cl^- has one more electron than protons / Cl has 17 electrons and 17 protons **and** Cl^- has 18 electrons and 17 protons so electrons are held less tightly / Cl 2, 8, 7 **and** Cl^- 2, 8, 8 so electrons are held less tightly; ***[1]***

(e) (i) Na_2O ionic **and** SO_3 covalent;
Na_2O has ions which are free to move in the liquid state;
SO_3 has no free charged particles; ***[3]***

Accept "no free moving ions" / "no delocalized electrons".

(ii) Na_2O basic **and** SO_3 acidic; ***[1]***

(iii) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;
$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$; ***[2]***

Ignore state symbols.

(iv) oxidation of SO_2 by atmospheric oxygen / combustion of sulfur-containing fossil fuel/heavy industry/power plants/combustion engine;
acid rain / pollution of lakes and rivers / localized pollution in cities; ***[2]***

Accept specific examples of environmental effects such as corrosion of marble / limestone statues.

6. (a) loss of electrons; ***[1]***

(b) (i) +6/VI ; ***[1]***
Do not award mark if incorrect notation used, ie, 6 , 6+ or –6.

(ii) $C_4H_9OH(l) \rightarrow C_4H_8O(l) + 2H^+(aq) + 2e^-$; ***[1]***
Ignore state symbols.

(iii) $3C_4H_9OH(l) + Cr_2O_7^{2-}(aq) + 8H^+(aq) \rightarrow 3C_4H_8O(l) + 2Cr^{3+}(aq) + 7H_2O(l)$; ***[1]***
Ignore state symbols.

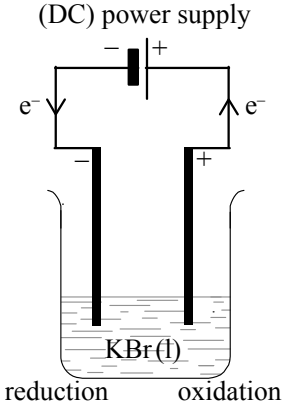
(iv) $CH_3CH_2CH_2CH_2OH$;
$(CH_3)_2CHCH_2OH$; ***[2]***
Accept full or condensed structural formulas.

(v) $(CH_3)_3COH$;
2-methylpropan-2-ol;
Allow 2-methyl-2-propanol , methylpropan-2-ol, methyl-2-propanol.

tertiary; ***[3]***

(vi) $C_4H_9OH + 6O_2 \rightarrow 4CO_2 + 5H_2O$ / $(CH_3)_3COH + 6O_2 \rightarrow 4CO_2 + 5H_2O$
correct reactants and products;
correct balancing; ***[2]***

(c) (i)



(DC) power supply / battery;
electrodes labelled as +/anode or –/cathode **and** electron flow;
reduction at negative electrode (cathode) / oxidation at positive electrode (anode);
electrolyte / molten KBr/KBr(l) / $K^+(l)$ **and** $Br^-(l)$; ***[4]***

(ii) *Positive electrode (anode):*
$2Br^-(l) \rightarrow Br_2(l) + 2e^-$;

Negative electrode (cathode):
$K^+(l) + e^- \rightarrow K(l)$; ***[2]***
*Award **[1 max]** if correct half-equations are given at the wrong electrodes.*
Allow e instead of e^-.
Ignore state symbols.
Penalize equilibrium sign once only.

(iii) positive ions move towards negative electrode (cathode) **and** negative ions move towards positive electrode (anode) / ions move to oppositely charged electrode / negative ions give up electrons at positive electrode **and** positive ions gain electrons at negative electrode; ***[1]***

(d) (i) Z < W < X < Y; ***[1]***
Accept Y > X > W > Z.

(ii) $X(s) + Z^{2+}(aq) \rightarrow X^{2+}(aq) + Z(s)$; ***[1]***
Ignore state symbols.
Accept $X(s) + ZCl_2(aq) \rightarrow XCl_2(aq) + Z(s)$.

7. (a) HCl is a strong acid **and** CH_3COOH is a weak acid so HCl has higher conductivity / HCl dissociates completely in water **and** CH_3COOH does not, so HCl has higher conductivity / HCl is stronger acid (than CH_3COOH) so has higher $[H^+]$ and higher conductivity; ***[1]***

(b) (i) $CH_3COOH(aq) + HCO_3^-(aq) \rightarrow CH_3COO^-(aq) + H_2O(l) + CO_2(g)$; ***[1]***
Accept $NaHCO_3(aq)$ and $CH_3COONa(aq)$ instead of ions.
Ignore state symbols.

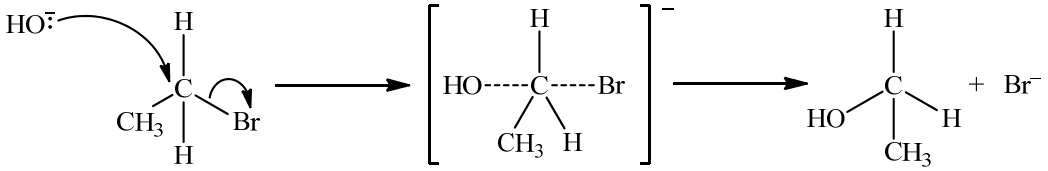
(ii) $n(CH_3COOH) = 0.00500\,(\text{mol})$ **and** $n(NaHCO_3) = 0.00450\,(\text{mol})$;
$NaHCO_3$ is limiting; ***[2]***

(iii) $n(CO_2) = n(NaHCO_3) = 0.00450\,(\text{mol})$;
$m(CO_2) = 0.00450 \times 44.01 = 0.198\,(\text{g})$; ***[2]***
*Award **[2]** for correct final answer.*

(c) (i) $T = 363\,\text{K}$ **and** $V = 9.50 \times 10^{-5}\,\text{m}^3$;
Accept $V = 9.5 \times 10^{-2}\,dm^3$ if P is used as 101 kPa in calculation.
$$n = \frac{PV}{RT} = \frac{1.01 \times 10^5 \times 9.50 \times 10^{-5}}{8.31 \times 363};$$
$$= 3.18 \times 10^{-3}\,(\text{mol});$$ ***[3]***
*Award **[3]** for correct final answer.*

(ii) $$M = \left(\frac{m}{n} = \frac{0.348}{3.18 \times 10^{-3}} =\right) 109\,(\text{g mol}^{-1});$$ ***[1]***

(d) (i) (dilute aqueous) NaOH/sodium hydroxide / KOH/potassium hydroxide; ***[1]***
Do not accept hydroxide/OH^-.

(ii) 

curly arrow going from lone pair/negative charge on O in HO^- to C;
Do not allow curly arrow originating on H in HO^-.

curly arrow showing Br leaving;
Accept curly arrow either going from bond between C and Br to Br in bromoethane or in the transition state.

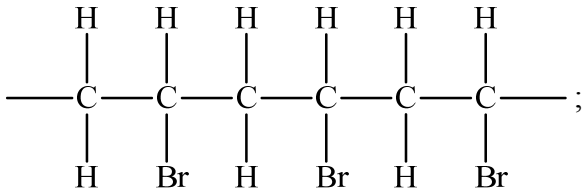
representation of transition state showing negative charge, square brackets and partial bonds;
Do not penalize if HO and Br are not at 180° to each other.
Do not award M3 if OH—C bond is represented. ***[3]***

(e) (i) HBr;
room temperature / anhydrous/dry; ***[2]***
Allow heat/warm.

(ii) *bonds broken:*
$1(\text{C=C}) + 1(\text{H–Br}) / (612 + 366 =) 978\,(\text{kJ})$;
Accept 2630 (kJ).

bonds formed:
$1(\text{C–C}) + 1(\text{C–H}) + 1(\text{C–Br}) / (1\times 347 + 1\times 413 + 1\times 290 =) 1050\,(\text{kJ})$;
Accept 2702 (kJ).

$\Delta H = -72\,(\text{kJ mol}^{-1})$; ***[3]***
*Award **[3]** for correct final answer.*
*Award **[2 max]** for +72 (kJ mol^{-1}).*

(f)  ; ***[1]***
Extension bonds required.
Ignore brackets and n.