Diploma Programme
Programme du diplôme
Programa del Diploma

# Markscheme

## May 2015

## Chemistry

## Standard level

## Paper 2

11 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) $(\pm)0.10\,(\text{cm}^3)$; **[1]**

*Accept $\pm 0.1$ ($cm^3$).*
*Accept ($\pm$) 0.09 ($cm^3$) (based on more accurate method of calculating propagation of uncertainties).*

(b) $\left(\frac{12.70+12.50}{2}=\right)12.60\,(\text{cm}^3)$;

$(0.01260\times 0.100=)1.26\times 10^{-3}\,(\text{mol})$; **[2]**

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

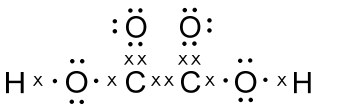
(c) (i) $\left(\frac{1.26\times 10^{-3}}{2}=\right)6.30\times 10^{-4}\,(\text{mol})$; **[1]**

(ii) $(6.30\times 10^{-4}\times 10=)6.30\times 10^{-3}\,(\text{mol})$; **[1]**

(iii) $\left(\frac{0.795}{6.30\times 10^{-3}}=\right)126\ (\text{g mol}^{-1})$; **[1]**

(iv) $M_r(C_2H_2O_4)=90.04$ **and** $M_r(H_2O)=18.02$;
$x=2$; **[2]**
*Accept integer values for $M_r$'s of 90 and 18 and any reasonable calculation.*
*Award **[1 max]** if no working shown.*

(d) hydrogen bonding; **[1]**

(e)  ; **[1]**

*Mark cannot be scored if lone pairs are missing on oxygens.*
*Accept any combination of lines, dots or crosses to represent electron pairs.*

**2.** (a) $CH_4 + Br_2 \rightarrow CH_3Br + HBr$ ; **[1]**

(b) *Initiation:*

$Br_2 \xrightarrow{UV/hf/h\upsilon} 2Br\bullet$ ;

*Reference to UV/light or high temperatures must be included.*

*Propagation:*

$Br\bullet + CH_4 \rightarrow CH_3\bullet + HBr$ ;

$CH_3\bullet + Br_2 \rightarrow CH_3Br + Br\bullet$ ;

*Termination:*

*Award **[1 max]** for any one of:*

$Br\bullet + Br\bullet \rightarrow Br_2$ ;

$CH_3\bullet + Br\bullet \rightarrow CH_3Br$ ;

$CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$ ; **[4 max]**

*Accept representation of radical without • (eg Br, $CH_3$) if consistent throughout mechanism.*

*Award **[3 max]** if initiation, propagation and termination are not stated or are incorrectly labelled for equations.*

(c) *Positive electrode (anode):*

$2Br^- \rightarrow Br_2(g) + 2e^- / Br^- \rightarrow \frac{1}{2}Br_2(g) + e^-$ ;

*Negative electrode (cathode):*

$Na^+ + e^- \rightarrow Na(l)$ ; **[2]**

*Award **[1 max]** for correct equations at incorrect electrodes.*
*Ignore state symbols.*
*Accept e instead of $e^-$.*
*Penalize use of equilibrium signs once only.*

(d) bromine/$Br_2$; **[1]**

*Do not accept bromide/$Br^-$.*

**3.** (a) change in concentration of reactant/product with time / rate of change of concentration; **[1]**
*Accept "increase" instead of "change" for product and "decrease" instead of "change" for reactant.*
*Accept "mass/amount/volume" instead of "concentration".*
*Do not accept substance.*

(b) collision frequency;
two particles must collide;
particles must have sufficient energy to overcome the activation energy/ $E \geq E_a$ ;
*Concept of activation energy must be mentioned.*

appropriate collision geometry/orientation; **[3 max]**

**4.** (a)

| | *Relative mass* | *Relative charge* |
|---|---|---|
| *Proton* | 1 | +1 |
| *Electron* | $5\times10^{-4}$ | –1 |
| *Neutron* | 1 | 0 |

;; **[2]**
*Award **[2]** for all four correct.*
*Award **[1]** for two or three correct.*

(b) (i) *Neutrons:* 36 **and** *Electrons:* 29; **[1]**

(ii) *Physical:*
$^{63}$Cu lower boiling point/melting point/density/greater rate of diffusion than $^{65}$Cu;
*Accept converse arguments.*
*Do not accept "different mass".*

*Chemical:*
(properties identical because) same electron configuration/arrangement of electrons; **[2]**
*Accept "same number of protons **and** electrons".*
*Do not accept "same number of electrons" OR "same valence (electrons)" OR "same atomic number" only.*

(c) electrostatic attraction;
between (a lattice of) cations/positive ions **and** delocalized/sea of electrons; **[2]**
*Do not award any mark for only stating "metallic bonding".*

(d) *Award **[1]** for any **two** of:*
malleable / ductile / conducts electricity / conducts heat / durable / strong / resistant to corrosion / low reactivity; **[1]**

## Section B

**5.** (a) (i) *Equation:*
$CH_2CH_2 + H_2O \rightarrow CH_3CH_2OH$ / $C_2H_4 + H_2O \rightarrow C_2H_5OH$;

*Conditions*:
(concentrated) sulfuric acid/$H_2SO_4$;
*Do not accept dilute sulfuric acid.*
*Accept phosphoric acid/$H_3PO_4$ (on pellets of silicon dioxide) (for industrial preparation).*

heat / high temperature; **[3]**
*Do not accept warm.*
*Accept high pressure (for industrial preparation) for M3 only if $H_3PO_4$ is given for M2.*

(ii) 1.5 ($dm^3$); **[1]**

(b) (i) energy needed to break (1 mol of) a bond in the gaseous state/phase;
(averaged over) similar compounds; **[2]**
*Do not accept "similar bonds" instead of "similar compounds".*
*Concept of "similar" is important for M2.*

(ii) $CH_3CH_2OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$;
*Bonds broken:*
$347 + (5 \times 413) + 358 + 464 + (3 \times 498) / 4728\,(kJ)$ /
C–C + 5C–H + C–O + O–H + 3O=O;
*Bonds made:*
$(4 \times 746) + (6 \times 464) / 5768\,(kJ)$ / 4C=O + 6O–H;
$\Delta H = (4728 - 5768 =) -1040\,(kJ\,mol^{-1})$ / bonds broken – bonds formed; **[4]**
*Award **[4]** for correct final answer.*
*Award **[3]** for (+)1040 (kJ $mol^{-1}$).*

(iii) ethanol and water are liquids / not all molecules are gaseous / in enthalpy of combustion molecules are in their standard states / bond enthalpies are average values; **[1]**
*Do not accept answer "ethanol/water is a liquid" alone.*

(iv) less energy required to break bonds in reactants than is released when the bonds in products form / bonds stronger (overall) in products/weaker (overall) in reactants; **[1]**

(c) alcohols / alkanols;

*Any two of the following for **[2 max]**:*
differ by $CH_2$/methylene (unit);
similar chemical properties;
gradually changing physical properties;
same general formula;
same functional group; **[3]**
*Do not accept "same" instead of "similar", or vice-versa.*

(d) mass/volume of water measured;
mass ethanol/spirit burner measured before **and** after burning;
alcohol heats water (in a calorimeter) **and** temperature change of water measured;
$q = m \times c \times \Delta T$ ;
*Students must make it clear that m is the mass of $H_2O$.*

$\Delta H = -\frac{q}{n}$ ; **[5]**

*Students must make it clear that n is the moles of ethanol.*

**6.** (a) ability of atom/nucleus to attract bonding/shared pair of electrons / attraction of nucleus for bonding/shared pair of electrons; **[1]**
*Do not accept "element" instead of "atom/nucleus".*
*Do not accept "electrons" alone.*

(b) increasing nuclear charge/increasing number of protons / increased attraction of (valence) electrons to nucleus;
electrons added are in same (outer) energy level; **[2]**

(c) (i) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;
*Accept* $Na_2O(s) + H_2O(l) \rightarrow 2Na^+(aq) + 2OH^-(aq)$.

$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$; **[2]**
*Accept* $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$.
*Accept* $P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H^+(aq) + 4H_2PO_4^-(aq)$.
*Ignore state symbols.*

(ii) *NaOH:* > 7;
*Accept any pH greater than 7.*

$H_3PO_4$ *:* < 7; **[2]**
*Accept any pH less than 7.*

*Award **[1 max]** if stated that "NaOH alkali/basic **and** $H_3PO_4$ acidic", but pH values not given.*

(d) measuring electrical conductivity **and** strong acids have greater electrical conductivity/weak acids have lower electrical conductivity;
*Do not accept conductivity for electrical conductivity.*
*Accept explanation in terms of lightbulb in circuit.*

measure pH/use universal indicator **and** pH higher for weak acid/pH lower for strong acid;

conduct titration with a strong base **and** equivalence point higher for weak acid / buffer region for weak acid;

adding a reactive metal/carbonate/hydrogen carbonate **and** stronger effervescence/faster reaction with strong acids;
*Accept converse argument.*
*Accept correct example.*

adding a strong base **and** strong acid would increase more in temperature/weak acids increase less in temperature; **[3 max]**
*Accept correct example.*

*Award **[1 max]** for three suitable tests without correct results.*
*Accept specific examples with given strong acid and weak acid.*
*Accept "addition of $AgNO_3$ (aq) **and** white precipitate with HCl (aq)".*
*Do not accept "smell".*

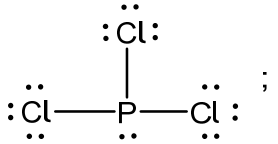
(e) Lewis acid (only);
electron pair acceptor / not a proton donor; **[2]**

(f) (i) *Bonding:* (electrostatic) attraction between oppositely charged ions;
*Do not accept ionic bonding without some description.*

*Structure:* lattice/giant structure of ions / each $Na^+$ surrounded by 6 $Cl^-$ (and vice-versa); **[2]**

(ii) $Na_2S$ ;
$Mg_3P_2$ ; **[2]**

(g) *Lewis structure:*



*Accept any combination of lines, dots or crosses to represent electron pairs.*
*Do not award the mark if lone pairs are missing.*

*Name of shape:*
(trigonal/triangular) pyramidal;

*Bond angle:*
$< 109.5^{\circ}$ ;
*Accept any value within the range* $100^{\circ} - 109^{\circ}$ .
*Literature value is 100° .*

*Explanation of polarity:*
dipoles do not cancel (as molecule is not symmetrical) / there is a net dipole (as molecule is not symmetrical) / unsymmetrical distribution of charge; **[4]**
*Accept suitable labelled diagram.*

*No ECF if original structure is incorrect.*

**7.** (a) (i) temperature $= 358\,\text{K}$ ;

$$M = \frac{mRT}{pV} / 1.17 \times 8.31 \times \frac{358}{(0.40 \times 101)} ;$$

$(M =)\ 86.2\,(\text{g mol}^{-1})$ ; **[3]**

*Award **[1 max]** for correct final answer without working.*

(ii) $C_6H_{14}$ ; **[1]**

(b) $C(CH_3)_4$;

*Accept correct name 2,2-dimethylpropane.*
*Do not penalize missing H atoms.*

weakest London/dispersion/van der Waals'/vdW/instantaneous induced dipole-induced dipole forces because of smallest surface area/contact
OR
weakest London/dispersion/van der Waals'/vdW/ instantaneous induced dipole-induced dipole forces because of least distortion of the electron cloud
OR
weakest London/dispersion/van der Waals'/vdW/ instantaneous induced dipole-induced dipole forces because polarizability of electrons (in electron cloud) is less; **[2]**

*Accept other words to that effect but student must mention a correct IMF and a correct reason.*

(c) (i) *Ethanal*: distill off product as it forms;
*Accept distillation.*

*Ethanoic acid*: (heat under) reflux / use excess oxidizing agent; **[2]**

(ii) *Ethanol:* –2/–II;
*Ethanal:* –1/–I; **[2]**
*Do not accept 2– or 1–, but penalize only once.*

(iii) $CH_3CH_2OH \rightarrow CH_3CHO + 2H^+ + 2e^-$; **[1]**
*Half-equation required. Do not accept* $C_2H_5OH + 2[O] \rightarrow CH_3CHO + H_2O$.
*Accept e for* $e^-$.

(iv) $3CH_3CH_2OH(aq) + Cr_2O_7^{2-}(aq) + 8H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3CH_3CHO(l) + 7H_2O(l)$
correct reactants and products;
correct balancing; **[2]**
*M2 can only be scored if M1 correct.*
*Ignore state symbols.*

(d) (i) rate of forward process/reaction = rate of backward/reverse process/reaction;
concentrations of reactants and products remain constant;
no change in macroscopic properties;
closed/isolated system / constant matter/energy; **[2 max]**

(ii) provides alternative pathway (of lower energy);
lowers activation energy (of the reaction) / more particles with $E \geq E_a$; **[2]**

(iii) no effect (on position of equilibrium);
increases rate of forward and reverse reactions (equally); **[2]**

(e) decreases; **[1]**