Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2015

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.

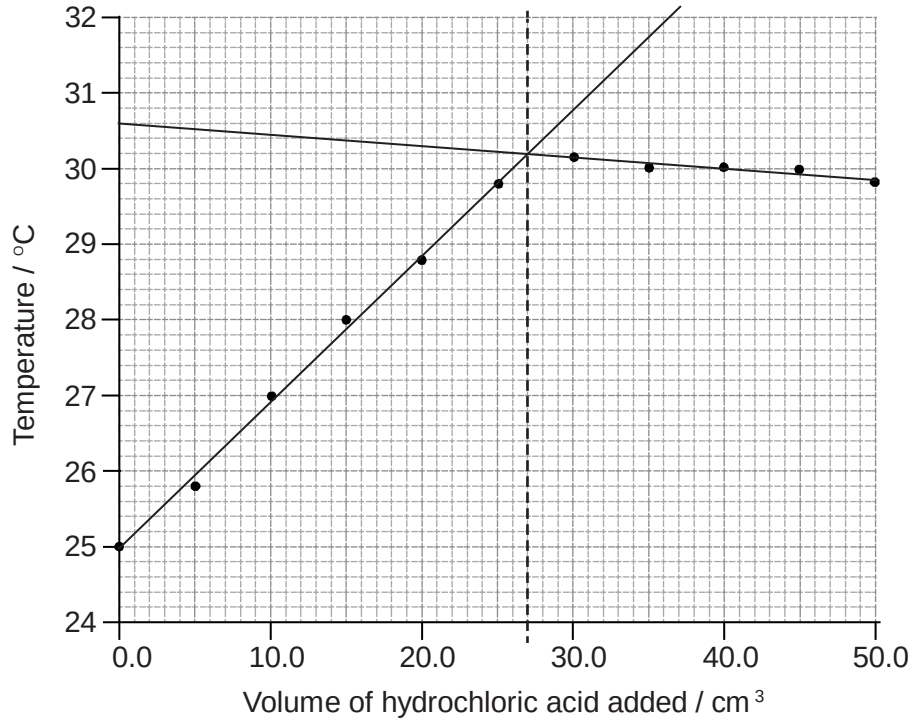
12. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.

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

14. Penalize missing hydrogens or incorrect bond linkages (*eg* C–H_3C) once only.

Section A

1. (a) (i)



drawing best-fit straight lines to show volume;
There should be approximately the same number of points above and below for both lines.

27.0 (cm^3); **[2]**
Accept any value in the range 26.0 to 28.0 (cm^3) if consistent with student's annotation on the graph.
Accept ECF for volumes in the range 27.0–30.0 cm^3 if it corresponds to maximum temperature of line drawn.
Volumes should be given to one decimal place.

(ii) $[HCl] = \frac{1.00 \times 0.0250}{0.0270}$;

$= 0.926\,mol\,dm^{-3}$; **[2]**

Volume of 26.0 gives [HCl] = 0.962 mol dm^{-3}. Volume of 28.0 gives [HCl] = 0.893 mol dm^{-3}
*Award **[2]** for correct final answer with units.*
*Award **[1 max]** for correct concentration without units.*
Accept M, mol L^{-1}, mol/dm^3 as units.

(b) (i) $(30.2 - 25.0 =)(+)5.2(^{\circ}\text{C/K})$; **[1]**

Any accepted value must be consistent with student's annotation on the graph but do not accept $\Delta T < 5.1$.
Accept (+)5.6$(^{\circ}\text{C/K})$ *(ie, taking into account heat loss and using T when volume = 0.0 cm*^{3}*).*

(ii) $Q = (m \times c \times \Delta T = (25.0 + 27.0) \times 4.18 \times 5.2 = 1130.272\,\text{J} =) 1.13\,(\text{kJ})$;
$n = (1.00 \times 0.0250 =) 0.0250\,(\text{mol})$;
$\Delta H = (-\frac{Q}{n} = -45210.88\,\text{J mol}^{-1} =) -45\,(\text{kJ mol}^{-1})$; **[3]**

Award ***[3]*** *for correct final answer.*
Award ***[2]*** *for +45 (kJ mol* $^{-1}$*).*
Apply ECF for M3 even if both m and ΔT *are incorrect in M1.*
Accept use of c = 4.2 Jg^{-1}*K*$^{-1}$*.*

(iii) $\left(\left| \frac{-45 - (-58)}{(-58)} \right| \times 100 = \right) 22\,(\%)$; **[1]**

Answer must be given to two significant figures.
Ignore sign.

(iv) heat losses;
better (thermal) insulation / using a polystyrene cup / putting a lid on the beaker; **[2]**
Accept other suitable methods for better thermal insulation, but do not accept just "use a calorimeter" without reference to insulation.

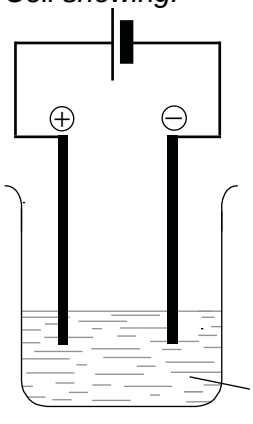
2. (a) *Protons:* 12
Neutrons: 14
Electrons: 11 **[2]**
Award ***[2]*** *for three correct answers.*
Award ***[1]*** *for two correct answers.*
Award ***[0]*** *for one correct answer.*

(b) bombardment/collision (of Mg atom) with high energy electrons / *OWTTE*; **[1]**

(c) (Mg^+ ion passes through) electric field/potential difference/oppositely charged plates; **[1]**

(d) $^{24}\text{Mg} = (100 - 10.00 - 11.01 =) 78.99\,\%$;
$A_r = (24 \times 0.7899 + 25 \times 0.1000 + 26 \times 0.1101 =) 24.32$; **[2]**
Award ***[2]*** *for correct final answer which must be to two decimal places.*
Do not accept data booklet value of 24.31.

3. (a) (i) *Cell showing:*



molten electrolyte/$MgCl_2(l)$, electrodes **and** battery/DC supply;
correct labelling of positive electrode/anode/+ **and** negative electrode/cathode/–; **[2]**

(ii) *Positive electrode (anode):*
$2Cl^-(l) \rightarrow Cl_2(g) + 2e^-$ / $Cl^-(l) \rightarrow \frac{1}{2}Cl_2(g) + e^-$;
Negative electrode (cathode):
$Mg^{2+}(l) + 2e^- \rightarrow Mg(l)$;
Accept e instead of e^-.
*Award **[1 max]** for correct half-equations given at the wrong electrode.*
Penalize use of reversible arrows once only.

correct state symbols in both equations; **[3]**

(b) ions are not free to move when solid / ions in rigid lattice / *OWTTE*; **[1]**

(c) aluminium/Al is less dense (compared to iron/Fe) / Al is more ductile or malleable / aluminium forms a protective oxide layer / Al does not corrode / iron/Fe rusts / *OWTTE*; **[1]**
Do not accept "Al is lighter" OR "less expensive" OR "Al can be recycled".

4. (a) same functional group;
same general formula;
(successive members) differ by CH_2;
similar chemical properties;
gradation in physical properties; **[2 max]**
Do not accept "same" instead of "similar", or vice versa.

(b) Initiation:
$Br_2 \xrightarrow{UV/hf/h\nu} 2Br\bullet$;
Reference to UV light or high temperature must be included.
Propagation:
$Br\bullet + C_2H_6 \rightarrow C_2H_5\bullet + HBr$;
$C_2H_5\bullet + Br_2 \rightarrow C_2H_5Br + Br\bullet$;
Termination:
$Br\bullet + Br\bullet \rightarrow Br_2$ / $C_2H_5\bullet + Br\bullet \rightarrow C_2H_5Br$ / $C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$; **[4]**
Accept representation of radical without • (eg, Br, C_2H_5) if consistent throughout mechanism.
Penalize reference to heterolytic fission once only.
*Award **[0]** to any mechanism involving ions.*
Accept further bromination.
*Award **[3 max]** if initiation, propagation **and** termination are not stated or are incorrectly labelled for equations.*
Accept correct description of processes without equations.

Section B

5. (a) rates of forward **and** reverse reactions are equal / opposing changes occur at equal rates;
the concentrations of all reactants **and** products remain constant / macroscopic properties remain constant;
closed/isolated system; **[2 max]**
Accept "the same" for "equal" in M1 and for "constant" in M2.

(b) $(K_c =) \frac{[NH_3(g)]^2}{[N_2(g)] \times [H_2(g)]^3}$; **[1]**
Ignore state symbols.
Concentration must be represented by square brackets.

(c) *The volume of the container is increased:*
position of equilibrium shifts to the left/reactants **and** fewer moles of gas on the right hand side/pressure decreases / *OWTTE*;

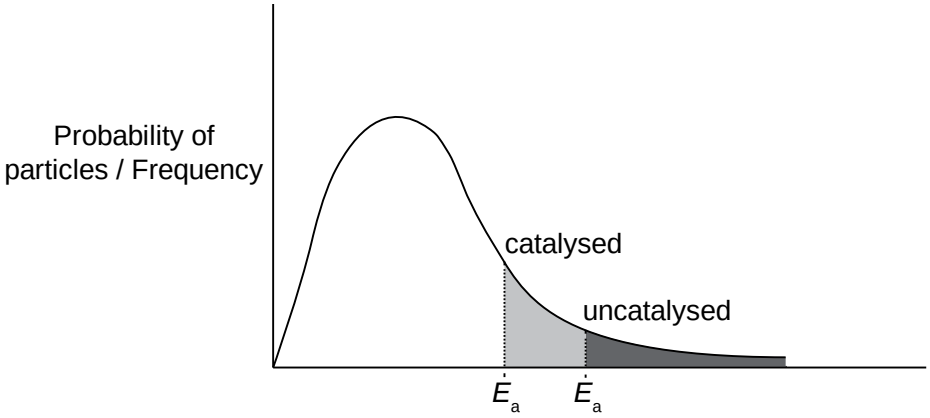
Ammonia is removed from the equilibrium mixture:
position of equilibrium shifts to the right/products **and** $[NH_3]$ decreases so $[N_2]$ and $[H_2]$ must also decrease to keep K_c constant
OR
position of equilibrium shifts to the right/products **and** rate of reverse reaction decreases / *OWTTE*; **[2]**
*Award **[1 max]** if both predicted changes are correct.*
Do not accept "to increase $[NH_3]$" or reference to LCP without explanation.

(d) (i) <u>minimum</u> energy needed (by reactants/colliding particles) to react/start/ initiate a reaction; **[1]**
Accept "energy difference between reactants and transition state".

(ii) rate increases;
more effective/successful collisions per unit time / greater proportion of collisions effective;

alternative pathway **and** a lower activation energy
OR
lowers activation energy so that more particles have enough energy to react; **[2 max]**
Do not accept just "lowers/reduces the activation energy".
Accept "provides a surface for reacting/reactants/reaction".

(iii) *Curve showing:*



general shape of Maxwell-Boltzmann energy distribution curve **and** *labelled y-axis:* probability of particles / frequency **and** *labelled x-axis:* (kinetic) energy;
Curve must begin at zero and must not cut the x-axis on the RHS.
Accept number/fraction/proportion of particles for y-axis label, but do not accept amount or just particles.

correct position of E_a catalysed **and** E_a uncatalysed; **[2]**
Shading shown in the diagram is not required for the marks.

(e) (i) slower rate / *OWTTE*;
uneconomic / *OWTTE*; **[2]**

(ii) high cost for building/maintaining plant / high energy cost of compressor / *OWTTE*; **[1]**
Do not accept "high pressure is expensive" without justification.
Accept high pressure requires high energy.

(f) (i) electron pair donor; **[1]**
Accept lone pair donor.

(ii) proton acceptor **and** partially/slightly ionized; **[1]**
*Accept "proton acceptor **and** partially/slightly dissociated".*

(iii)

Acid		*Conjugate base*
$CH_3NH_3^+$	**and**	CH_3NH_2;
H_2O	**and**	OH^-;

[2]
*Award **[1 max]** for two correct acids OR two correct conjugate bases.*

(iv) solutions of equal concentration;
pH measurement/UIP;
strong base has higher pH;

OR

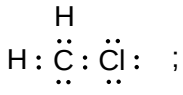
solutions of equal concentration;
electrical conductivity measurement;
strong base has higher electrical conductivity;

OR

solutions of equal concentration;
temperature difference in neutralization reaction with a strong acid;
strong base has a greater temperature difference; **[3]**

Accept reverse arguments for observations.

6. (a) (i)



; **[1]**

Accept any combination of lines, dots or crosses to represent electron pairs.

(ii) *Shape:* tetrahedral;
Bond angle: accept any value in the range: 108° to 111°; **[2]**
(Literature value is 108.2°.)

(iii) Cl is more electronegative than C / C–Cl bond polar;
bond dipoles do not cancel / asymmetric distribution of electron cloud / (resultant) net dipole moment (from vectorial addition of bond dipoles) going in direction of C–Cl axis / *OWTTE*; **[2]**

(iv) hydrogen bonding in methanol;
stronger than dipole-dipole/van der Waals' attractions/forces in chloromethane; **[2]**
Accept converse argument.

(b) (i) $2K(s) + Cl_2(g) \rightarrow 2KCl(s)$; **[1]**
Ignore state symbols.

(ii) (electrostatic) attraction between lattice of cations/<u>positive</u> ions and delocalized electrons; **[1]**

(iii) (electrostatic) attraction between positively charged nuclei and a pair of electrons;
formed as a result of electron sharing; **[2]**

(iv) (electrostatic) attraction between positive and negative ions/oppositely charged ions/cations and anions;
formed as a result of transfer of an electron from a K atom to a Cl atom / *OWTTE*; **[2]**

(v) amount of potassium $= \left(\frac{0.0587}{39.10} = \right) 1.50 \times 10^{-3} (\text{mol})$;

$2K + 2H_2O \rightarrow 2KOH + H_2$ / amount of hydrogen $= 7.50 \times 10^{-4} (\text{mol})$;

volume of hydrogen $= (7.50 \times 10^{-4} \times 22.4 \times 1000 =) 16.8 (\text{cm}^3)$; **[3]**

Accept calculation of volume of hydrogen using $PV = nRT$ (answer is 16.9 cm^3).
*Award **[3]** for correct final answer.*

(c) (i) *Na, Mg (oxides):* basic

Al (oxide): amphoteric
Do not accept amphiprotic.

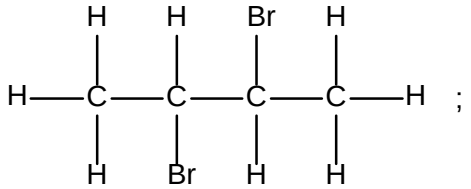
Si to Cl (oxides): acidic **[2]**

*Award **[2]** for all three listed sets correct.*
*Award **[1]** for one or two listed sets correct.*
*Award **[1]** for stating oxides become more acidic towards right/Cl or more basic towards left/Na.*
Do not penalize if reference is to Ar instead of Cl.
Do not penalize for incorrect formulas of oxides.

(ii) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$;
$P_4O_{10}(s) + 6H_2O(l) \rightarrow 4H_3PO_4(aq)$; **[2]**

Ignore state symbols.
Accept $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$.
Do not award marks if incorrect formulas of the oxides are used.

7. (a) (i)



; **[1]**

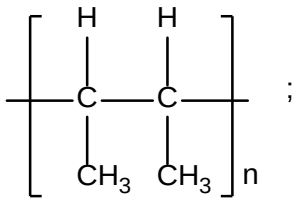
Accept bromine atoms cis to each other.

(ii) 2,3-dibromobutane; **[1]**
Do not penalize the incorrect use of spaces, comma or hyphen.

(iii) red/brown/orange/yellow to colourless/decolourized; **[1]**
Do not accept clear.
Do not accept just "decolourized".

(b) water;
sulfuric acid / phosphoric acid; **[2]**
Accept formulas instead of names.

(c) (i) (synthesis of) plastics/polymers/organic materials not naturally available / synthetic materials;
wide range of uses/physical properties / versatile;
large industry / many tons of plastics consumed by society / *OWTTE*; **[2 max]**
Do not accept "useful" for M2.
*Award **[1 max]** if specific addition polymer and its use is given.*
Penalize reference to condensation polymers once only.

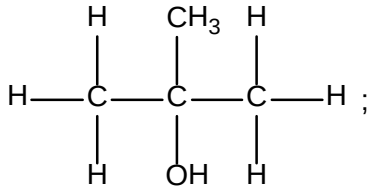
(ii)  ; **[1]**

Ignore n.
Brackets are not required for the mark, but continuation bonds are.
Do not penalize if methyl groups are trans to each other.

(d) (i) aqueous sodium hydroxide/NaOH/potassium hydroxide/KOH **and** warm/heat/reflux; **[1]**

(ii) (nucleophilic) substitution; **[1]**
Accept (nucleophilic) displacement.

(e) (i) carbonyl; **[1]**
Accept ketone.

(ii)  ; **[1]**

Accept condensed or full structural formula.

(f) hydrogen bonding in compound **C**;
dipole-dipole forces in **C** / **C** is more polar;
C has greater molar mass/more dispersion/London/instantaneous induced dipole-induced dipole forces/van der Waal forces; **[2 max]**
Accept converse argument.
*Award **[1 max]** for stronger intermolecular forces.*

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

average value in similar compounds / *OWTTE*; **[2]**

(ii) $C_4H_9OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$; **[1]**
Ignore state symbols.

(iii) *Bonds broken:*
$3C–C + 9C–H + 1C–O + 1O–H + 6O=O$ /
$3 \times 347 + 9 \times 413 + 1 \times 358 + 1 \times 464 + 6 \times 498 / 8568\,(kJ)$;
Bonds formed:
$8C=O + 10O–H / 8 \times 746 + 10 \times 464) / 10608\,(kJ)$;
$\Delta H = (8568 - 10608) = -2040\,(kJ mol^{-1})$; **[3]**
*Award **[3]** for correct final answer.*
*Award **[2]** for +2040 (kJ mol^{-1}).*