Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2015

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.

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 <u>underlined</u> are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

Section A

1. (a) (i) IO_3^- *to* I_2 : V/+5 to 0; ***[2]***

I^- *to* I_2 : −I/−1 to 0;

Accept change in oxidation number −5 and +1.

Penalize incorrect notation such as 5+ or 5 once only.

(ii) *Oxidizing agent*: IO_3^- /iodate **and** *Reducing agent*: I^- /iodide; ***[1]***

(b) (i) 1.4 (%); ***[1]***

Accept 1 (%).

(ii) systematic;
dilute the orange juice; ***[2]***

Accept other valid suggestions, eg compare with a standard (showing colour at equivalence) / look at mixture through a yellow filter / add more starch (for a sharper colour change) / filter orange juice (through charcoal).

Do not accept repeat the titration or alternative indicator.

(iii) 1.44×10^{-5} (mol); ***[1]***

(c) IO_3^- : $3C_6H_8O_6$ / 1:3 mole ratio;

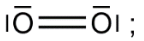
$(1.44 \times 10^{-5} \times 3 =)\ 4.32 \times 10^{-5}$ (mol); ***[2]***

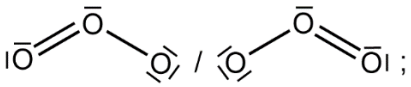
*Award **[2]** for the correct final answer.*

*Award **[1 max]** for "4.80 x 10^{-6} (mol)" obtained from reversed ratio,3:1.*

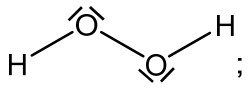
(d) $(4.32 \times 10^{-5} \times 176.14 =)\ 7.61 \times 10^{-3}$ (g); ***[1]***

Accept M_r = 176 and mass = 7.60×10^{-3} (g).

2. (a)  ;

 ;

The coordinate bond may be represented as an arrow and the formal charges may be shown.
Do not accept delocalized structure.

 ; ***[3]***

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

(b) $O_2 < H_2O_2$ **and** O_2 has double bond/bond order of 2 (and H_2O_2 has single bond/bond order of 1); ***[1]***
Do not apply ECF from part (a).

(c) Any value in the range 110° to <120°;
Experimental value = 117°.
Accept <120°.
Do not accept > 109°.

3 negative charge centres/electron domains with 1 lone pair / lone pair-bond (pair) repulsion greater than bond (pair)-bond (pair) repulsion / lone pair occupies more space than bond (pair)/shared pair (so O–O–O angle reduced); ***[2]***

Do not apply ECF in this question.

3. (a) $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$; ***[1]***
Ignore state symbols.

(b) *bonds broken:* 2(C–C)/694 + 8(C–H)/3304 + 5(O=O)/2490 / 6488 (kJ);
bonds made: 6(C=O)/4476 + 8(O–H)/3712 / 8188 (kJ);
(6488 − 8188 =) − 1700 (kJ); ***[3]***
Ignore signs in M1 and M2.
*Award **[3]** for the correct final answer.*
*Award **[2]** for +1700 (kJ).*
Accept values from 2016 data booklet to give 6494 (kJ) for M1, 8528 (kJ) for M2, and −2034 (kJ) for M3.

(c) $3C(s) + 3O_2(g) \rightarrow 3CO_2(g) / 3(-394) / -1182$;
$4H_2(g) + 2O_2(g) \rightarrow 4H_2O(g) / 4(-242) / -968$;
$C_3H_8(g) \rightarrow 3C(s) + 4H_2(g) / +104$;
$(-1182 + (-968) + 104 =) - 2046\,(kJ\,mol^{-1})$; ***[4]***
*Award **[4]** for the correct final answer.*
*Award **[3]** for +2046 / 2046 (kJ mol^{-1}).*

(d) part (b) values are based on average (bond enthalpy) values / part (c) values are for specific compounds; ***[1]***

4. (a) (i) ability of an atom to attract (a pair of) electrons in a covalent bond/molecule / ability of an atom to attract a shared pair of electrons; ***[1]***
Do not accept nucleus/element instead of atom.

(ii) do not form bonds/compounds / do not share electrons / have (full/stable) octet / have full/stable outer shell; ***[1]***
Accept (chemically) inert / do not react / stable electron arrangements/ configurations.

(b) *(Li → Cs)* atomic/ionic radius increases;
attraction between metal ions and <u>delocalized</u> electrons decreases;
Accept metallic bonding gets weaker.

(F → I) London/dispersion/instantaneous induced dipole-induced dipole forces increase;
Accept vdW/van der Waals' forces for London/dispersion forces.

with increasing number of electrons/molar mass/surface area/size of electron cloud; ***[3 max]***
Do not accept "with increasing size" or "with increasing mass" only.

Section B

5. (a) (i) *Increasing the pressure, at constant temperature:*
decreases;
more (gas) molecules/moles on the right / fewer (gas) molecules/moles on the left;

Increasing the temperature, at constant pressure:
increases;
(forward) reaction is endothermic; ***[4]***

(ii) (increasing) temperature **and** (K_c) increases; ***[1]***
*Award **[0]** if both temperature and pressure stated.*

(iii) equilibrium reached faster;
no change in the concentration of reactants/products/yield (at equilibrium) / position of equilibrium is not affected;
rates of forward and reverse reactions increase (equally);
reduces activation energy;
no change in K_c; ***[3 max]***

(b) (i) *Reaction A*: base **and** accepts a proton/H^+;
Accept donates a pair of electrons.

Reaction B: acid **and** donates/loses a proton/H^+; ***[2]***

*Award **[1]** if base and acid identified correctly without reasons.*

(ii)

	Acid		Base
Conjugate acid-base pair 1/2	H_2CO_3	**and**	HCO_3^-;
Conjugate acid-base pair 2/1	HCO_3^-	**and**	CO_3^{2-};
Conjugate acid-base pair 1/2	H_3O^+	**and**	H_2O;

[2 max]

(c) (i) *strong acid:* (assumed to be) completely/100 % dissociated/ionized **and**
weak acid: partially dissociated/ionized; ***[1]***

(ii) *Similarity*: bubbling/effervescence/gas / heat/increase in temperature / solid dissolves;
Difference: strong acid more vigorous / faster reaction / greater temperature increase; ***[2]***
Accept converse statements for weak acid.

(iii) 10^4(:1) / 10^{-1}:10^{-5} / 1:10^{-4}; ***[1]***
Do not accept inverse ratio, 1:10^4.

(d) (i) Na **and** Mg: basic
Al: amphoteric
Do not accept amphiprotic.

Si **to** Cl: acidic
Ar: no oxide ;; ***[2]***
*Award **[2]** for three or four correct, award **[1]** for two correct.*
*Award **[1]** for stating oxides become more acidic towards the right/chlorine or more basic towards the left/sodium.*
Do not penalize incorrect formulas of oxides.

(ii) $Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq)$ / $Na_2O(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l)$;
Accept a correct equation with any acid or acidic oxide.

$SO_3(l) + H_2O(l) \rightarrow H_2SO_4(aq)$ / $SO_3(l) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$; ***[2]***
Accept a correct equation with any metal hydroxide, metal oxide, metal carbonate or metal hydrogen carbonate.
Do not accept equation with SO_2.

Ignore state symbols.
Accept ionic equations for M1 and/or M2.

6. (a) (i) use of colorimeter/colorimetry;
measure change/decrease in intensity of (purple) colour;
recording of colour intensity at regular time intervals / recording time needed for colour to disappear;
calibration curve with known concentration;
Accept any three points.

OR

use of (analytical) balance/scale;
change/decrease in mass of reaction mixture;
recording of mass at regular time intervals / recording time needed for mass to become constant;

OR

use of gas syringe / inverted gas tube;
change/increase volume of carbon dioxide;
recording of volume at regular time intervals / recording time needed for volume to become constant;

OR

use of pH meter/probe;
change/increase in pH of reaction mixture;
recording of pH at regular time intervals / recording time needed for pH to become constant;

OR

use of conductivity meter/probe;
change/decrease in conductivity of reaction mixture;
recording of conductivity at regular time intervals / recording time needed for conductivity to become constant;

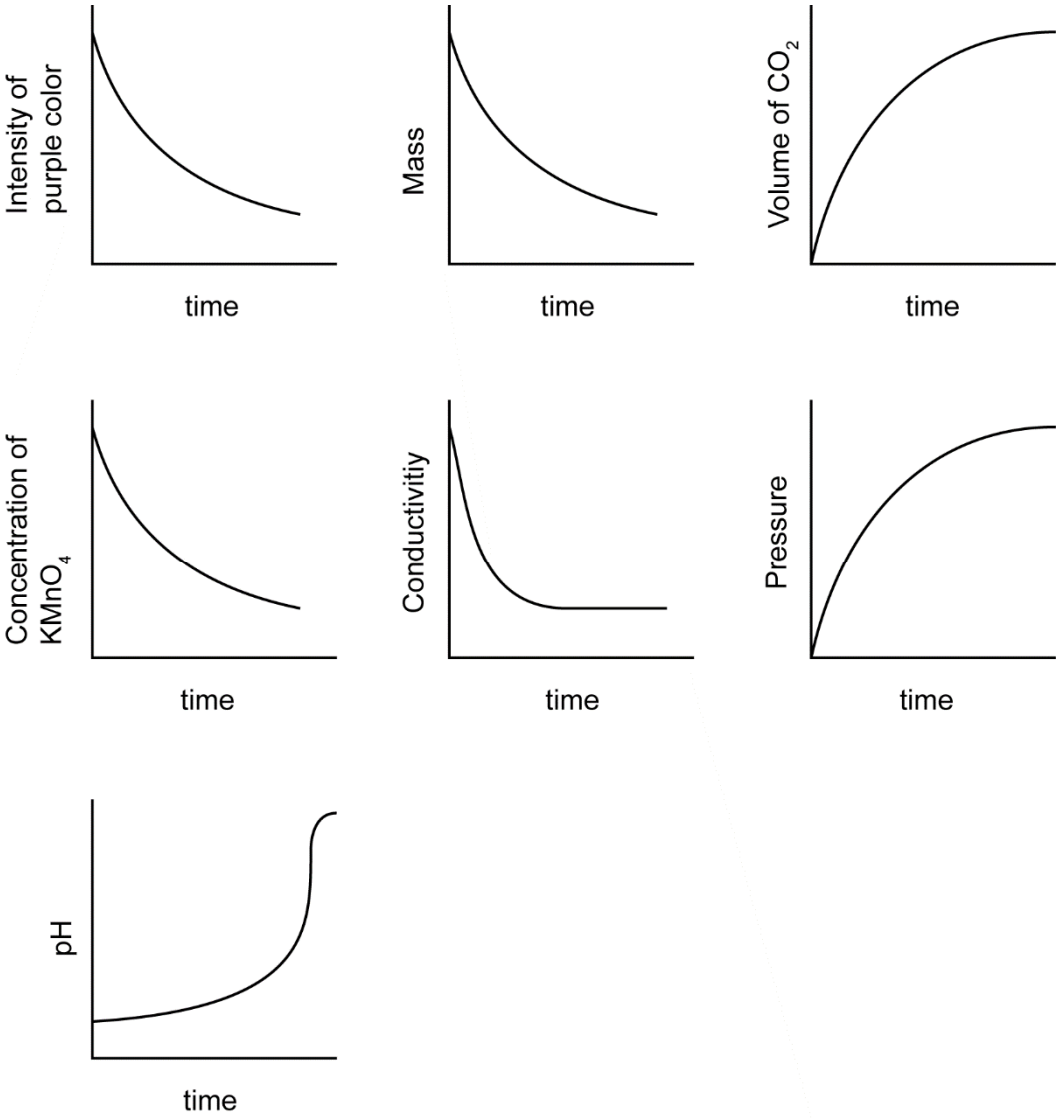
OR

use of pressure sensor;
change/increase in pressure of gas;
recording of pressure at regular time intervals / recording time needed for pressure to become constant; ***[3]***

(ii) axes labelled correctly;
Units not required for axes.

correct shape of curve; ***[2]***
Curve must have a slope of a gradually decreasing magnitude (except the pH curve) but does not have to show the end of the reaction/plateau.
Accept curve to start or end at zero or non-zero.
Accept slight initial horizontal line for mass, volume and pressure curves due to slight solubility of CO_2 released.
Accept zero-order graphs.
M2 can only be scored if M1 correct.

Examples of graph:



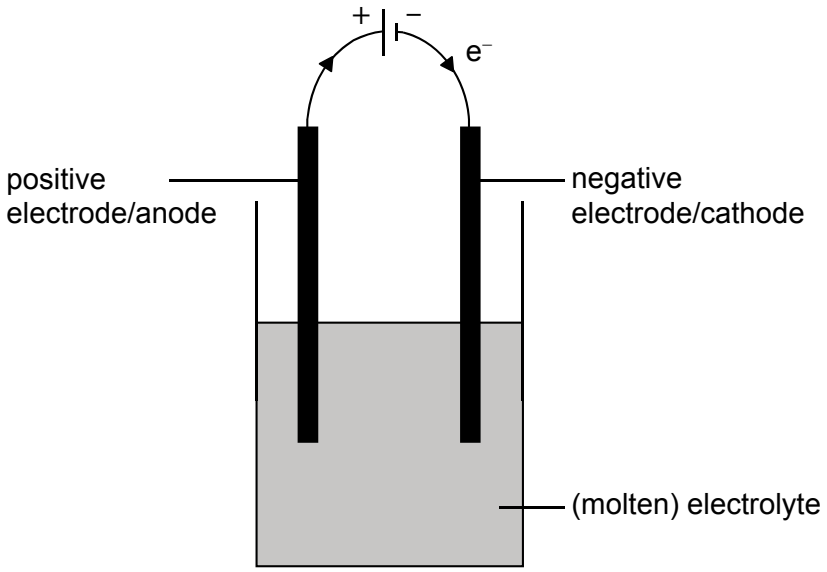
(iii) rate = slope/gradient of tangent; ***[1]***

(iv) (rate increases due to)
increase in (average) kinetic energy/speed of the particles;
increase in frequency of collisions/collisions per unit time;
greater proportion/number of particles have energy $\geq E_a$; ***[3]***

(b) (i) $Pb < Ni < Fe < Zn$;; ***[2]***
*Award **[2]** for the correct order.*
*Award **[1]** for $Zn > Fe > Ni > Pb$ as metals not listed in order of increasing reactivity.*
*Award **[1]** if one error in the order.*

(ii) Pb^{2+} / lead(II) (ions); ***[1]***
Do not accept Pb/lead.

(c) power source **and** direction of e^- movement;
labelled +/positive electrode/anode **and** –/negative electrode/cathode **and** (molten) electrolyte/$NiBr_2$ (l);
Accept polarity of electrodes given at the power source.



Negative electrode (cathode) : $Ni^{2+} + 2e^- \rightarrow Ni(l)$;

Positive electrode (anode): $2Br^- \rightarrow Br_2(g) + 2e^-$ / $Br^- \rightarrow \frac{1}{2}Br_2(g) + e^-$; ***[4]***

*Award **[1 max]** for M3 and M4 if equations are given at wrong electrodes.*
Ignore state symbols and reversible sign.
Allow e instead of e^-.

(d) (i) ionization **and** (bombardment) by high energy/fast moving electrons/electron gun (to form positive ions);
acceleration **and** passing through electric field/potential difference/oppositely charged plates;
deflection **and** passing through magnetic field/electromagnet; ***[3]***
*Award **[1]** for naming 3 processes (ionization, acceleration, deflection) in the correct order with incorrect details.*

(ii) to avoid collision with other particles (in the atmosphere) / allows ions to pass through unhindered (by air molecules); ***[1]***
Reference must be made to interaction with other particles.

7. (a) (i) $RBr(l) + NaOH(aq) \rightarrow ROH(aq) + NaBr(aq)$ /
$RBr(l) + OH^-(aq) \rightarrow ROH(aq) + Br^-(aq)$; ***[1]***
Ignore state symbols.

(ii) $(1.35 \times 10^{-2} - 7.36 \times 10^{-3} =) 6.14 \times 10^{-3}$ / 6.1×10^{-3} (mol); ***[1]***

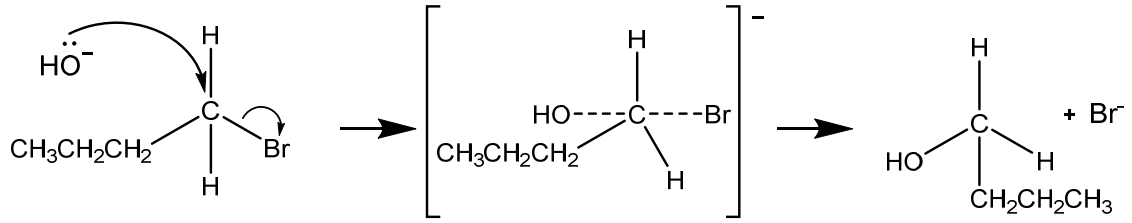
(iii) $\left(\text{molar mass} = \frac{0.842}{6.14 \times 10^{-3}} =\right) 137$ (g mol^{-1}); ***[1]***
Accept 138.

(iv) ($137 - 80 = 57$ which corresponds to C_4H_9, hence molecular formula) C_4H_9Br; ***[1]***
Do not accept ECF from 7a(iii) for an impossible molecular formula, such as $C_4H_{10}Br$.
Accept correct structural formula of one of the isomers as the molecular formula.

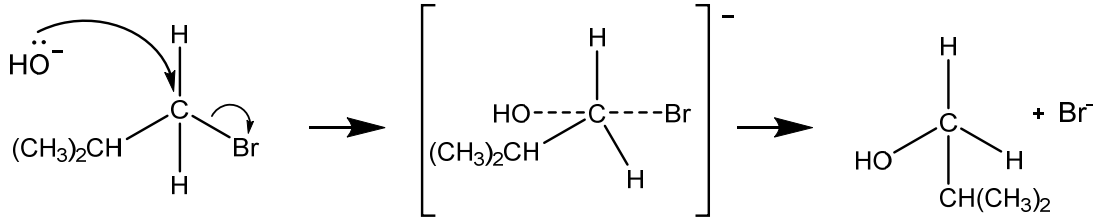
(v) $CH_3CH_2CH_2CH_2Br$ **and** primary;
$(CH_3)_2CHCH_2Br$ **and** primary;
$CH_3CHBrCH_2CH_3$ **and** secondary;
$(CH_3)_3CBr$ **and** tertiary;
*If primary, secondary or tertiary not stated, award **[3]** for four correct, **[2]** for three correct and **[1]** for two correct structural formulas.*
Penalize missing hydrogens once only.
Accept either full or condensed structural formulas.

If $C_5H_{11}Br$ was used, accept any correct structural formulas.
$CH_3CH_2CH_2CH_2CH_2Br$ **and** primary;
$(CH_3)_2CHCH_2CH_2Br$ **and** primary;
$CH_3CH_2CH(CH_3)CH_2Br$ **and** primary;
$(CH_3)_3CCH_2Br$ **and** primary;
$CH_3CHBrCH_2CH_2CH_3$ **and** secondary;
$CH_3CH_2CHBrCH_2CH_3$ **and** secondary;
$CH_3CHBrCH(CH_3)_2$ **and** secondary;
$CH_3CH_2C(CH_3)_2Br$ **and** tertiary; ***[4]***
*If primary, secondary or tertiary not stated, award **[3]** for four correct, **[2]** for three correct and **[1]** for two correct structural formulas.*
Penalize missing hydrogens once only.
Accept either full or condensed structural formulas.

(b)



OR



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

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

representation of transition state showing negative charge, square brackets and partial bonds; ***[4]***
Do not penalize if OH and Br are not at 180° to each other.

formation of products $CH_3CH_2CH_2CH_2OH/(CH_3)_2CHCH_2OH$ **and** Br^-;

Penalize incorrect side-chain, missing hydrogens and/or incorrect bond linkages (eg OH–C instead of HO–C) only once in this question.
Do not penalize missing hydrogens if already penalized in part 7 (a)(v).
*Award **[2 max]** if S_N1 mechanism is given.*

(c) (i) $CH_3CH_2CH_3 < CH_3CHO < CH_3CH_2OH < CH_3COOH$;; ***[2]***
*Award **[2]** for correct order.*
*Award **[1]** if one error in the order.*
*Award **[1]** for $CH_3COOH > CH_3CH_2OH > CH_3CHO > CH_3CH_2CH_3$ as compounds are not listed in order of increasing boiling point.*

(ii) $CH_3CH_2CH_3$ London/dispersion/instantaneous induced dipole-induced dipole forces
CH_3CHO dipole-dipole forces (and London/dispersion forces)
CH_3CH_2OH H-bonding (and dipole-dipole and London/dispersion forces)
CH_3COOH H-bonding (and dipole-dipole and London/dispersion forces) ;;
*Award **[2]** for all four correct.*
*Award **[1]** for two or three correct.*

H-bonding strongest / London/dispersion forces weakest / dipole-dipole stronger than London/dispersion / dipole-dipole weaker than H-bonding;

Accept vdW/van der Waals' forces for London/dispersion forces.

CH_3COOH forms more/stronger H-bonds than CH_3CH_2OH / CH_3COOH is more polar than CH_3CH_2OH; ***[4]***
Accept CH_3COOH has more electrons/higher molar mass than CH_3CH_2OH.

(iii) CH_3COOH;
Accept either full or condensed structural formula.

orange to green; ***[2]***