N15/4/CHEMI/SP2/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2015

Chemistry

Standard level

Paper 2

14 pages

International Baccalaureate
Baccalauréat International
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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.

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;

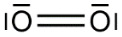
$(1.44 \times 10^{-5} \times 3 =)$ 4.32×10^{-5} (mol); ***[2]***

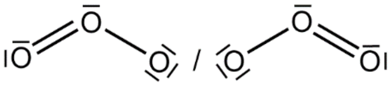
*Award **[2]** for the correct final answer.*

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

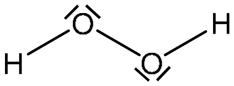
(d) $(4.32 \times 10^{-5} \times 176.14 =)$ 7.61×10^{-3} (g); ***[1]***

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 ;

$(-1182 + (-968) + 104 =) - 2046\,(\text{kJ mol}^{-1})$; ***[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;

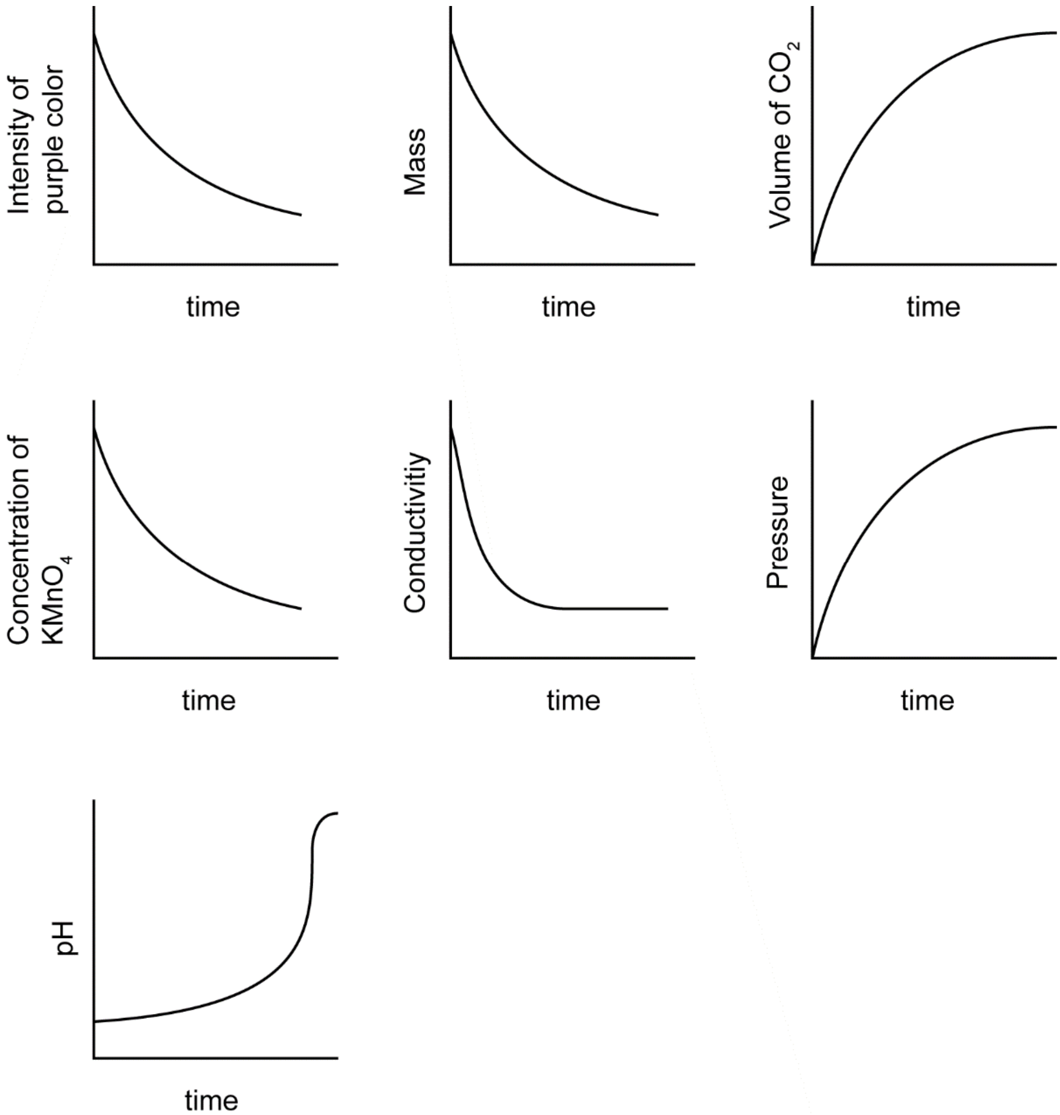
OR

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:



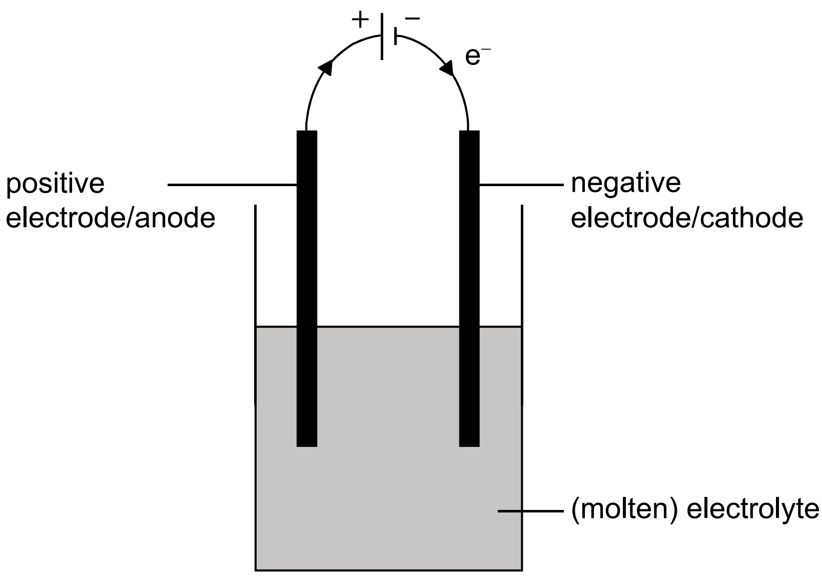
(iii) rate = slope/gradient of tangent; ***[1]***

(iv) (rate increases due to)
increase in (average) <u>kinetic</u> energy/speed of the particles;
increase in frequency of collisions/collisions per unit time;
greater proportion/number of particles have energy ≥ 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]***

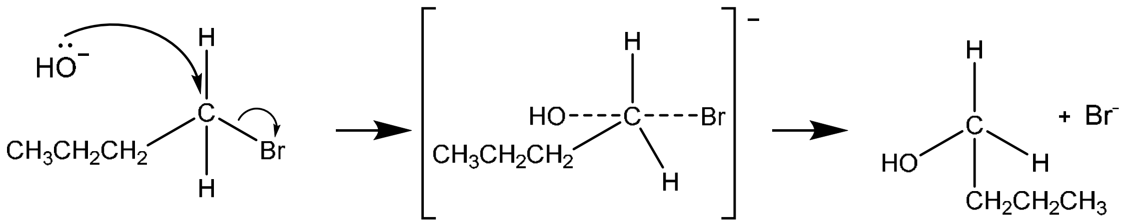
(iii) $\left(\text{molar mass} = \frac{0.842}{6.14 \times 10^{-3}} =\right) 137\ (\text{g mol}^{-1})$; ***[1]***
Accept 138.

(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.

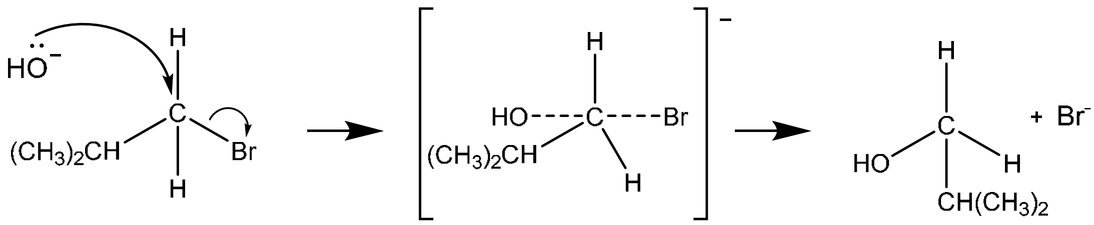
(v) $CH_3CH_2CH_2CH_2Br$ **and** primary;
$(CH_3)_2CHCH_2Br$ **and** primary;
$CH_3CHBrCH_2CH_3$ **and** secondary;
$(CH_3)_3CBr$ **and** tertiary;
*If primary, secondary or tertiary not stated, award **[3]** for four correct, **[2]** for three correct and **[1]** for two correct structural formulas.*
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]**