N12/4/CHEMI/SP2/ENG/TZ0/XX/M

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# MARKSCHEME

## November 2012

## CHEMISTRY

## Standard Level

## Paper 2

15 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) *$I_2(s)$*: four/4 **and** *$ICl(l)$*: three/3; ***[1]***

(ii) $n(Cl_2) = \left(\frac{2.24}{2 \times 35.45} =\right) 0.0316 / 3.16 \times 10^{-2}$ (mol);
*Allow answers such as $3.2 \times 10^{-2}$/0.032/$3.15 \times 10^{-2}$/0.0315 (mol).*

$n(ICl) = 2 \times 0.0316$ / 0.0632/$6.32 \times 10^{-2}$ (mol);
*Allow answers such as $6.4 \times 10^{-2}$/0.064/$6.3 \times 10^{-2}$/0.063 (mol).*

$m(ICl) = (0.0632 \times 162.35 =) 10.3$ (g); ***[3]***
*Allow answers in range 10.2 to 10.4 (g).*
*Award **[3]** for correct final answer.*

(iii) $\left(\frac{8.60}{10.3} \times 100 =\right) 83.5\%$; ***[1]***
*Allow answers in the range of 82.5 to 84.5%.*

(iv) negative/–/minus/ $< 0$; ***[1]***

(b) $Br_2$ has London/dispersion/van der Waals' forces/vdW **and** ICl has (London/dispersion/van der Waals' forces/vdW and) dipole–dipole forces;
dipole–dipole forces are stronger than London/dispersion/van der Waals'/vdW forces ; ***[2]***
*Allow induced dipole-induced dipole forces for London forces.*
*Allow interactions instead of forces.*
*Do not allow ICl polar and $Br_2$ non-polar for M1.*
*Name of IMF in both molecules is required for M1 and idea of dipole-dipole stronger than vdW is required for M2.*

(c) (i) $\left(\frac{126.90}{330.71} \times 100\right) = 38.4\%$; ***[1]***

(ii) $(25.25 - 1.05) = 24.20$ ($cm^3$); ***[1]***
*Accept 24.2 ($cm^3$) but not 24 ($cm^3$).*

(iii) $\left(\frac{24.20 \times 5.00 \times 10^{-2}}{1000}\right) = 1.21 \times 10^{-3} / 0.00121$(mol); ***[1]***

(iv) $(0.5 \times 1.21 \times 10^{-3}) = 6.05 \times 10^{-4} / 0.000605$(mol); ***[1]***
*Accept alternate method e.g. (0.384/126.9×0.2015) = $6.10 \times 10^{-4}$/0.000610 (mol).*

(v) $(126.90 \times 6.05 \times 10^{-4}) = 7.68 \times 10^{-2} / 0.0768\,(\text{g})$; ***[1]***
*Accept alternate method e.g. $(6.10 \times 10^{-4} \times 126.9)$ or $(0.2015 \times 0.384) = 7.74 \times 10^{-2} / 0.00774$ (g).*

(vi) $\left(\frac{7.68 \times 10^{-2}}{0.2015} \times 100\right) = 38.1\,\%$; ***[1]***
*Answer must be given to <u>three</u> significant figures.*

(d) ICl / iodine monochloride; ***[1]***
*Do not accept iodine or bromine.*

**2.** (a) energy needed to break (1 mol of) a bond in a <u>gaseous</u> molecule/state/phase;
average calculated from a range of similar compounds / *OWTTE*; ***[2]***
*Do not accept similar bonds instead of similar compounds.*
*M2 can be scored independently.*

(b) (i) *Bonds breaking*:
$2 \times (\text{C–C}) + 8 \times (\text{C–H}) + 3.5 \times (\text{O=O})$
$= (2)(347) + (8)(413) + (3.5)(498)$
$= 5741\,(\text{kJ mol}^{-1})$;

*Bonds forming*:
$3 \times (\text{CO}) + 8 \times (\text{O–H})$
$= (3)(1072) + (8)(464) = 6928\,(\text{kJ mol}^{-1})$;

*Enthalpy change*:
$(5741 - 6928 =) -1187\,(\text{kJ mol}^{-1})$; ***[3]***
*Award **[3]** for correct final answer.*

(ii) $NH_4^+$/ammonium / $N_2H_5^+$/hydrazinium / $CH_3NH_3^+$/methylammonium/ methanaminium / $H_2NO_3^+$ /nitrooxonium; ***[1]***

**3.** (a) rate of forward process/reaction = rate of backwards/reverse process/reaction / rate of vaporization/evaporation = rate of condensation;
concentrations of reactants and products remain constant;
no change in macroscopic properties / closed system / constant matter/energy / *OWTTE*; ***[1 max]***
*Do not accept concentration of reactants and products are equal.*
*Accept constant colour of $Br_2$ vapour/liquid.*

(b) (i) $(K_c =) \frac{[SO_3]^2}{[SO_2]^2[O_2]}$; ***[1]***

(ii)

| | Position of equilibrium | Value of $K_c$ |
|---|---|---|
| Decrease in temperature | shifts to right/products | increases |
| Increase in pressure | shifts to right/products | no effect |
| Addition of a catalyst | no effect | no effect |

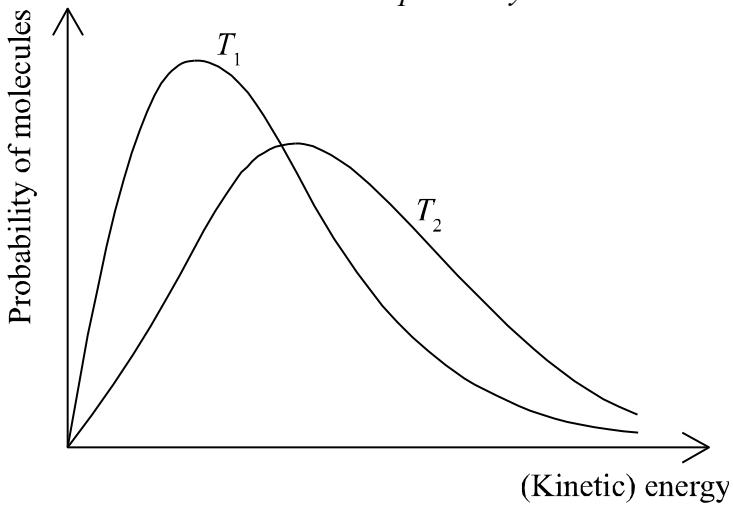
***[3]***
*Award **[1]** for any two or three correct, **[2]** for any four or five correct, **[3]** for six correct.*

(c) (i) minimum/least/smallest energy needed (by reactants/colliding particles) to react/start/initiate a reaction; ***[1]***
*Allow energy difference between reactants and transition state.*

(ii) *x-axis label*: (kinetic) energy/(K)E **and** *y-axis label*: probability/fraction of molecules/particles / probability density;
*Allow number of molecules/particles for y-axis.*

correct shape of a typical Maxwell–Boltzmann energy distribution curve;
*Do not award mark if curve is symmetric, does not start at zero or if it crosses x-axis.*

two curves represented with second curve for $T_2 > T_1$ to right of first curve, peak maximum lower than first curve and after the curves cross going to the right, $T_2$ curve needs to be above $T_1$ curve as illustrated;
*M2 and M3 can be scored independently.*




***[3]***

## SECTION B

**4.** (a) (i) *Atomic number*:
number of protons (in nucleus/atom);

*Mass number*:
(sum of) number of protons **and** neutrons (in nucleus/atom);

*Isotopes of an element*:
atoms of same element / atoms with same number of protons/atomic number/Z but different number of neutrons/mass number/*A*; ***[3]***

*Penalize once only use of the term element in the three definitions, for example, number of protons in an element or number of protons and neutrons in an element or element with the same atomic number but different mass number.*

(ii) *Group*: (elements in vertical) columns in periodic table **and** *Period*: (elements in horizontal) rows in periodic table; ***[1]***
*Allow elements in same group have similar chemical properties **and** within a period, atoms have same number of shells/energy levels (but number of electrons in valence/outer shell increases).*
*Allow groups distributed vertically **and** periods distributed horizontally / OWTTE.*
*Allow group number gives number of valence/outer shell electrons (for main-group elements) **and** period gives same number of shells/energy levels.*

(iii) $Li^+$: $2/1s^2$;
*B:* $2,3/1s^2 2s^2 2p^1$; ***[2]***

(iv) correct mathematical expression set-up (*e.g.* $\left(\frac{x}{100}\right)(10)+\left[\frac{(100-x)}{(100)}\right](11)=10.81$);
19 %; ***[2]***
*Award **[2]** for correct final answer.*

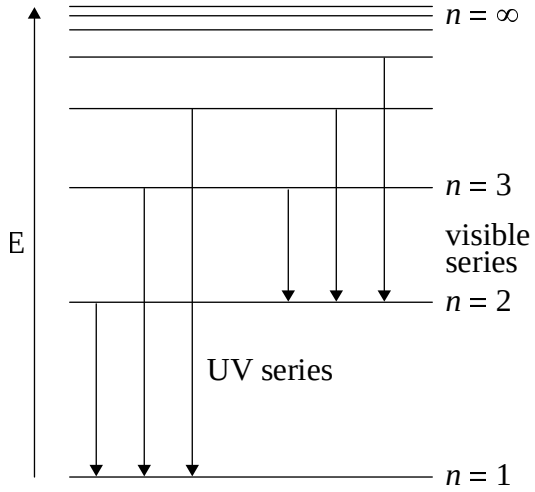
(v)

| Mass number (*A*) | Number of protons | Number of electrons | Number of neutrons |
|---|---|---|---|
| 6 | 3 | 3 | 3 |
| 7 | 3 | 3 | 4 |

***[2]***

*Award **[1 max]** for correct number of neutrons for both isotopes if numbers of protons or electrons is not given.*
*Award **[1 max]** for correct number of protons and electrons for both isotopes if number of neutrons is not given or if numbers of neutrons are incorrect.*

(b) (i) *Continuous spectrum:* radiation spread over all wavelengths/frequencies/ energies/colours / *OWTTE*;
*Line spectrum:* radiation (absorbed/emitted) at certain/specific wavelengths/ frequencies/energies/colours / *OWTTE*; ***[2]***
*Allow series of (separate/discrete) lines which converge/get closer together at high energy / OWTTE.*

(ii) 

showing *y*-axis labelled as energy/E **or** labelling at least two energy levels ($n = 1$, $n = 2$ *etc*. but not for $n = 0$);
showing energy levels converging;
showing jumps to $n = 1$ for ultraviolet series;
showing jumps to $n = 2$ for visible series; ***[4]***
*UV and visible must be labelled.*

(c) (i) metals have delocalized electrons / sea of electrons which are mobile/can move / *OWTTE*;
layers/positive ions/cations/atoms slide past/over each other / *OWTTE*; ***[2]***
*Do not accept nuclei for M2.*

(ii) $Fe^{2+}$ **and** $Fe^{3+}$ ; ***[1]***

(iii) *Lithium oxide*: $Li_2O$ **and** *Iron(II) oxide*: FeO; ***[1]***

**5.** (a) (i) *Oxidation:* loss of electrons **and** *Reduction:* gain of electrons; ***[1]***

(ii) $As_2O_3$: +3;
$NO_3^-$: +5;
$H_3AsO_3$: +3;
$N_2O_3$: +3; ***[4]***
*Penalize incorrect notation e.g. III, V, 3+, 5+, 3, 5 once only.*

(iii) *Oxidizing agent:* substance reduced / removes electrons from another substance / causes some other substance to be oxidized / *OWTTE* **and** *Reducing agent*: substance oxidized / gives electrons to another substance / causes some other substance to be reduced / *OWTTE*; ***[1]***
*Accept Oxidizing agent: electron/e/$e^-$ acceptor / causes oxidation / oxidation number/state decreases **and** Reducing agent: electron/e/$e^-$ donor / causes reduction / oxidation number/state increases.*

(iv) $As_2O_3(s) + 2NO_3^-(aq) + 2H^+(aq) + 2H_2O(l) \rightarrow 2H_3AsO_4(aq) + N_2O_3(aq)$
correct coefficients for $As_2O_3$, $H_3AsO_4$ **and** $NO_3^-$, $N_2O_3$;
correct balanced equation;
*Ignore state symbols.*
*M1 must be correct to award M2.*

*Oxidizing agent:* $NO_3^-(aq)$/nitrate **and** *Reducing agent:* $As_2O_3(s)$/arsenic(III) oxide; ***[3]***
*Accept $HNO_3$(aq)/nitric acid.*
*Accept arsenic oxide.*
*Species must be fully correct to score M3.*
*Ignore state symbols.*

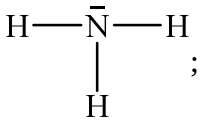
(b) (i) *Brønsted Lowry theory*: proton/$H^+$ donor;
*Lewis theory*: electron-pair acceptor; ***[2]***

(ii) N=O; ***[1]***

(iii) accept any value in range 102 – 105°;
*Actual value is 102°.*

lone/non-bonding pairs on oxygen occupy more space/repel more than bonding pairs hence decreasing the H–O–N bond angle (from 109.5°) / *OWTTE*; ***[2]***

(iv) *Strong acid:* acid/electrolyte completely/100% dissociated/ionized in solution/water / *OWTTE* **and** *Weak acid:* acid/electrolyte partially dissociated/ionized in solution/water / *OWTTE*; ***[1]***

(v)  ;

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

trigonal/triangular pyramidal;
*Accept pyramidal (since SL).*
*Do not allow tetrahedral.*

net dipole moment present in molecule / NH bond polarities do not cancel each other out / unsymmetrical distribution of charge /*OWTTE*; ***[3]***
*Do not accept molecule has no symmetry hence polar.*

(vi) changes by $10^2$/100 ; ***[1]***
*Allow changes from $10^{-5}$ to $10^{-7}$ .*

(vii) $(NH_4)_2SO_4$; ***[1]***

*Penalize missing hydrogens or incorrect bonding (e.g. C–H₃C) once only in **6**.*

**6.** (a) (i) (hydration of ethane) to manufacture ethanol / $C_2H_4 + H_2O \rightarrow C_2H_5OH$;
synthesis of $CH_3COOH$ / ethanoic acid;
*Allow acetic acid instead of ethanoic acid.*

synthesis of ethane-1,2-diol;
*Allow 1,2-ethanediol/1,2 ethandiol/ethylene glycol/glycol alcohol instead of ethane-1,2-diol.*

any appropriate polymerization of ethene; ***[2 max]***
*e.g. polyethene, polychloroethene/PVC, polyphenylethene/polystyrene/PS etc.*

*Accept other industrial uses such as ripening of fruits.*
*Do not accept manufacture of margarine/alcohol/plastics/polymers/fuel.*

(ii) compounds with the same molecular formula but different arrangement of atoms/structural formula/structures; ***[1]***
*Do not allow similar instead of same.*

(iii) (*cis*-)but-2-ene / (*Z*)but-2-ene / but-2-ene;
*Accept (cis-)2-butene / Z-2-butene.*
*Ignore missing hyphens.*

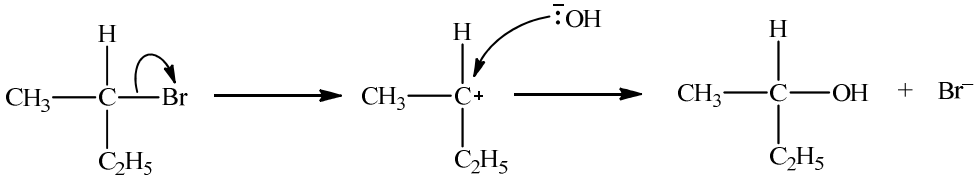
$CH_3CH_2CH=CH_2$;
$H_2C=C(CH_3)_2$; ***[3]***
*Accept either full or condensed structural formulas.*
*Allow structural formula of trans-but-2-ene.*

(iv) $(CH_3)CH=CH(CH_3) + HBr \rightarrow CH_3CHBrCH_2CH_3$; ***[1]***
*Allow* $C_4H_8 + HBr \rightarrow C_4H_9Br$.

(v) secondary/ $2^o$; ***[1]***

(vi) *Since secondary could be either $S_N1$ or $S_N2$ so allow $S_N1$ or $S_N2$ for M1–M4.*

*$S_N1$:*



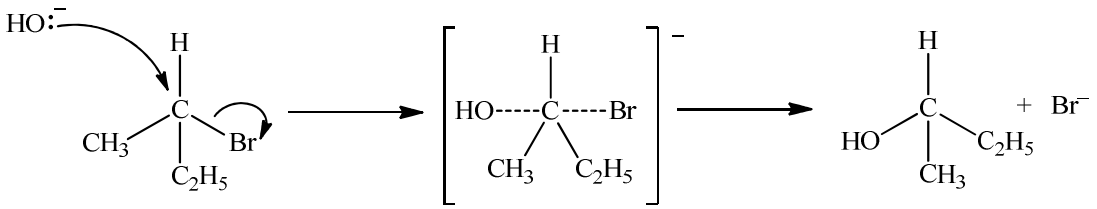
curly arrow showing Br leaving;
*Do not allow arrow originating from C to C–Br bond.*

representation of secondary carbocation;
curly arrow going from lone pair/negative charge on O in $HO^-$ to $C^+$;
*Do not allow arrow originating on H in $HO^-$.*

formation of organic product $CH_3CH(OH)C_2H_5$/$C_4H_9OH$ **and** $Br^-$;
*Allow formation of NaBr instead of $Br^-$.*

**OR**

*$S_N2$:*



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 2-bromobutane or in the transition state.*
*Do not allow arrow originating from C to C–Br bond.*

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.*

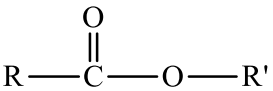
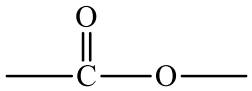
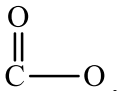
formation of organic product $CH_3CH(OH)C_2H_5$/$C_4H_9OH$ **and** $Br^-$; ***[4]***
*Allow formation of NaBr instead of $Br^-$.*

*For primary **Z** from (v), for ECF $S_N2$ required.*
*For tertiary **Z** from (v), for ECF $S_N1$ required.*
*But curly arrow showing Br leaving and formation of $C_4H_9OH$ **and** $Br^-$ can be scored for either mechanism (even if incorrect type).*

*For primary **Z** from (v) with 1-bromobutane stated in (vi), correct $S_N2$ can score full marks.*
*If (v) is not answered and incorrect starting reagent is given in (vi), M1, M2 and M3 may be scored but not M4 for either correct $S_N1$ or $S_N2$.*

(vii) $CH_3COCH_2CH_3$;
*Full or condensed structural formula may be given.*
*For primary **Z** from (v), accept $CH_3CH_2CH_2COOH/C_3H_7COOH$ but not $CH_3CH_2CH_2CHO$.*

ketone / alkanone; ***[2]***

(b) (i) drawing of RCOOR' group /  ***[1]***
*Allow C instead of R or R'.*
*Allow*  /  .

(ii) $(100 - 62.0 - 10.4 =)\ 27.6\ \%\ O$;
$n_C : \left(\frac{62.0}{12.01} =\right) 5.162\ (\text{mol})$ **and** $n_H : \left(\frac{10.4}{1.01} =\right) 10.297\ (\text{mol})$
**and** $n_O : \left(\frac{27.6}{16.00} =\right) 1.725\ (\text{mol})$;
dividing 5.162 and 10.297 by 1.725 (to get values $C_{2.992}H_{5.969}O_1$);
(empirical formula = ) $C_3H_6O$; ***[4]***
*Award **[4]** for correct final answer if alternative method used.*
*Allow integer values for atomic masses (i.e. 12, 1 and 16).*

(iii) $C_6H_{12}O_2$; ***[1]***