M12/4/CHEMI/HP2/ENG/TZ1/XX/M

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

MARKSCHEME

May 2012

CHEMISTRY

Higher Level

Paper 2

17 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through Scoris™, by e-mail or telephone – if through Scoris™ or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through Scoris™ or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of Scoris™, please contact emarking@ibo.org.

If you have any queries on **administration** please contact:

Rachel Bengough
Subject Operations
IB Assessment Centre
Peterson House
Malthouse Avenue
Cardiff Gate
Cardiff CF23 8GL
GREAT BRITAIN

Tel: +(44) 29 2054 7777

Fax: +(44) 29 2054 7778

E-mail: rachel.bengough@ibo.org

1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use Scoris™ annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an "NR" in the mark panel on the right-hand side of the screen.

7. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers. Scoris™ will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp 'seen' on any page that contains no other annotation.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the "CON" stamp.

Subject Details: Chemistry HL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[40 marks]** and **TWO** questions in Section B **[2 x 25 marks]**. Maximum total = **[90 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) bromine/Br_2; ***[1]***
Do not allow Br or bromide/Br^-.

(ii) 7.9×10^{-5} (mol dm^{-3} s^{-1});
The number of significant figures must be correct.
Allow 8.0×10^{-5} (mol dm^{-3} s^{-1}).

(only 2 significant figures) because of precision of time/[Br_2] measurements; ***[2]***
Allow answers based on rate laws or orders of reaction.
M2 can only be scored if M1 correct.

(iii) *[Br_2]:* 1% **and** *Time:* 0.8%;
Percentage Uncertainty: 1.8%; ***[2]***
Accept Percentage Uncertainty: 2%.
Do not allow answers based on rate laws or orders of reaction.

(b) (i) *CH_3COCH_3:* 1;
Br_2: 0;
H^+: 1; ***[3]***

(ii) rate = k [H^+] [CH_3COCH_3];
$k = 4.00\times10^{-3}$;
mol^{-1} dm^3 s^{-1}; ***[3]***

(c) (no it doesn't) actual reaction is zero order with respect to Br_2;
(no it doesn't) actual rate determining step/slow step does not involve Br_2 / *OWTTE;*

OR

(no it doesn't) reaction is first order with respect to H^+;
(no it doesn't) mechanism/rate determining step/slow step does not involve H^+ / *OWTTE;*

OR

(no it doesn't) reaction is first order with respect to CH_3COCH_3;
(no it doesn't) rate determining step/slow step does not involve CH_3COCH_3 / *OWTTE;* ***[2]***

Award no marks if yes stated.

2. (a) (i) $n(\text{Pb}): \left(\frac{64.052}{207.19}\right) = 0.30915\,(\text{mol})$

$n(\text{C}): \left(\frac{29.703}{12.01}\right) = 2.473\,(\text{mol})$

$n(\text{H}): \left(\frac{6.245}{1.01}\right) = 6.18\,(\text{mol})$

Do not penalize if integer values of atomic masses used.
Accept alternative calculation method.
*Award **[2]** for three correct.*
*Award **[1]** for any two correct.*

PbC_8H_{20}; ***[3]***

(ii) PbC_8H_{20}; ***[1]***

(iii) $PbC_8H_{20} + 14O_2 \rightarrow PbO_2 + 8CO_2 + 10H_2O$

correct reactants and products;
correct coefficients; ***[2]***
M2 can only be scored if M1 correct.

(b) *Local pollutant:*
carbon monoxide/CO / volatile organics/VOCs / nitrogen oxide/NO / (unburnt) hydrocarbons;
Do not accept methane/CH_4, ethane/C_2H_6, propane/C_3H_8 or butane/C_4H_{10}.

Global pollutant:
nitrogen oxide/NO / carbon dioxide/CO_2; ***[2]***
Accept nitrogen dioxide/NO_2 / NO_x for both local or global pollutant.
Accept other widely used names for NO such as nitric oxide/nitrogen monoxide/nitrogen(II) oxide or nitrogen(IV) oxide for NO_2.

3. (a) (carbon to carbon) double bond / alkene;
Accept if identified on diagram.

orange/brown/red/yellow to colourless / bromine is decolourized; ***[2]***
M2 can be only scored if M1 correct.

(b) (i) $COOH/CO_2H$ / carboxylic acid / alkanoic acid; ***[1]***
Do not allow carboxylic/alkanoic, carbonyl or carboxylate.

(ii) redox / oxidation (of alcohol); ***[1]***

(c) (i) aldehyde / alkanal / CHO; ***[1]***
Accept C=O / carbonyl.

(ii) **Z < X < Y**;
*Accept **Z**,**X**,**Y** or **ZXY**.*

no hydrogen bonding in **Z /** hydrogen bonding in **X and Y**;
*Accept statements such as **Z** has only van der Waals/London/dispersion forces **and** dipole-dipole forces.*

Y most polar / more electrons / forms dimers / forms two hydrogen bonds / greater molecular/molar mass; ***[3]***
*Do not accept **Y** has a larger mass.*

4. (a) $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$;
Fe/iron; ***[2]***
Do not accept Fe/Fe^{2+} half-equation or Fe^{2+}.

(b) $Mg(s) + Fe^{2+}(aq) \rightarrow Mg^{2+}(aq) + Fe(s)$; ***[1]***

(c) (i) (potential of reduction half-reaction) under standard conditions measured relative to standard hydrogen electrode/SHE / difference of standard reduction potential of substance undergoing reduction and standard reduction potential of substance undergoing oxidation / *OWTTE*; ***[1]***

(ii) (+)1.92 (V); ***[1]***

(d) (i) ***S:*** $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ / $2H^+(aq) + 2e^- \rightarrow H_2(g)$;
T: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$; ***[2]***

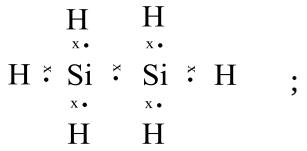
(ii) 1:1; ***[1]***

(iii) increase in current/voltage/surface area of electrodes; ***[1]***

(iv) oxygen;
$2H_2O \rightarrow O_2 + 4H^+ + 4e^-$ / $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$; ***[2]***

SECTION B

5. (a) (i)



;

[1]

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

(ii) 109° / 109.5° / 109° 28' ;
four/tetrahedrally arranged negative charge centres/electron domains/electron pairs (around central/silicon atom) / equal repulsion between bonding pairs (around central/silicon atom) / *OWTTE*; ***[2]***
M2 is an independent marking point.
Reference must be made to negative or electron.
Do not accept tetrahedral molecule.

(iii) sp^3; ***[1]***

(iv) C–H;
larger difference in electronegativity (for C–H bond) / smaller difference in electronegativity (for Si–H bond) / ΔEN (CH) = 0.4 **and** ΔEN (SiH) = 0.3; ***[2]***

(v) both (molecules) non-polar;
both (molecules) symmetrical / polar bond effects cancel out / *OWTTE*; ***[2]***

(vi) stronger/larger/greater van der Waals'/London/dispersion forces;
Do not accept stronger/larger/greater intermolecular forces.

more electrons / stronger instantaneous dipole; ***[2]***
Do not accept larger mass.

(b) (i) ($\sum \Delta H_f^\circ$ (products) =) –5360 (kJ);
($\sum \Delta H_f^\circ$ (reactants) =) +160 (kJ);
= –5520 (kJ); ***[3]***

(ii) (–1560 × 2 =) –3120 (kJ); ***[1]***

(iii) *Structure:*
CO_2 molecular **and** SiO_2 three-dimensional/network/giant lattice/giant covalent/macromolecular/repeating tetrahedral units;
CO_2 linear **and** SiO_2 tetrahedral;

Intramolecular Bonding:
covalent bonds in CO_2 **and** SiO_2;
double bonds in CO_2 **and** single bonds in SiO_2; ***[3 max]***
Accept diagrams showing bonding types (double and single) within the structures.

(c) *Bonds broken:*
6Si–H, Si–Si, H–H / (+)2570 (kJ);
Bonds formed:
8Si–H / (–)2544 (kJ);
+26 (kJ);

OR

Bonds broken:
Si–Si, H–H / (+)662 (kJ);
Bonds formed:
2Si–H / (–)636 (kJ);
+26 (kJ); ***[3]***

(d) (i) 1 to 3;
Accept any answer in this range: pH ≤ 3.

HCl/strong acid formed;
$SiCl_4(l) + 4H_2O(l) \rightarrow Si(OH)_4(s) + 4HCl(aq)$; ***[3]***

(ii) *Aqueous solution:*
mobile ions/charged particles present;

Liquid:
molecular covalent / no (mobile) charged particles/ions; ***[2]***

6. (a) $Br_2(g) \rightleftharpoons Br_2(l)$;
$H_2(g) + Br_2(g) \rightleftharpoons 2HBr(g)$; ***[2]***

(b) (i) increase volume of liquid / no change of colour of vapour; ***[1]***

(ii) shifts to right/toward products/forward reaction favoured; ***[1]***
Accept reverse statement if process written the other way around.
Answer must match stated equation.

(iii) no effect;
same amounts/number of (gaseous) moles/molecules on both sides; ***[2]***

(c) (i) $(K_c =) \frac{[HBr]^2}{[H_2][Br_2]}$; ***[1]***

(ii) no effect (only depends on the temperature); ***[1]***

(d) (i) *Strong acid:* acid/electrolyte (assumed to be almost) 100%/completely dissociated/ionized (in solution/water) / *OWTTE* **and** *Weak acid:* acid/electrolyte only partially/slightly dissociated/ionized (in solution/water) / *OWTTE*;
$HBr(aq) \rightarrow H^+(aq) + Br^-(aq)$;
$HF(aq) \rightleftharpoons H^+(aq) + F^-(aq)$; ***[3]***

(ii) *Data points:*
(0.00, 2.88) **and** (12.50, 4.77);

For first point also accept volume = 0.00 with pH in range 2.8–2.9.
For second point also accept either:
volume in range between 12.5–12.6 and pH 4.8–4.9
OR
volume in range between 25.0–25.2 and pH 8.0–10.0

For (0.00, 2.88):
$[H^+] = [F^-]$;
$pK_a = 2pH - 1$ / $K_a = \frac{[H^+]^2}{0.100}$;

For (12.50, 4.77):
$[HF] = [F^-]$;
$pK_a = pH$;

$pK_a = 4.77$; ***[6]***
Accept any value in range 4.7–4.9 if consistent with data points.
Accept alternative calculation method if other data points from the table or graph are used and the pK_a in correct range.

(iii) bromothymol blue / phenol red / phenolphthalein;
pK_a/end point of indicator in range 7–10 as pH at equivalence in range 7–10; ***[2]***

(e) (i) *Br_2:* 0
HBr: –1
HOBr: +1 ***[2]***
*Award **[2]** for three correct.*
*Award **[1]** for any two correct.*

(ii) bromine is oxidized **and** reduced / disproportionation; ***[1]***

(iii) $K_c < 1$; ***[1]***

(f) (i) F_2/fluorine; ***[1]***
Do not allow F.

(ii) 50 (cm^3) / 0.050 dm^3; ***[1]***

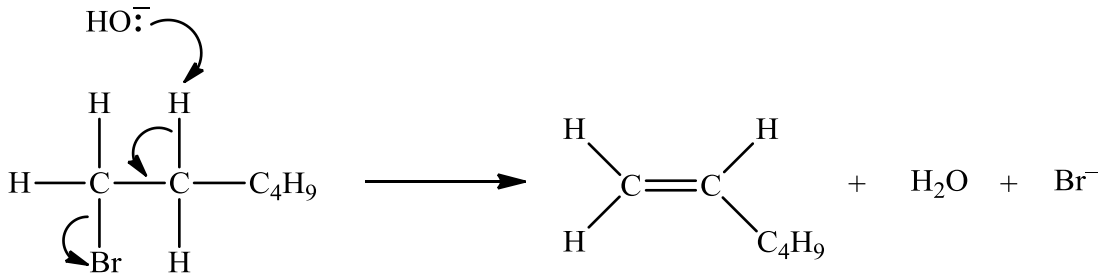
7. (a) (i) molar mass = 102.20 ($g\ mol^{-1}$);
amount $\left(= \frac{5.00}{102.20}\right) = 0.0489$ (mol); ***[2]***

(ii) theoretical yield = $(84.18 \times 0.0489 =)$ 4.12 (g);
percentage yield $= \left(\frac{2.62}{4.12} \times 100 =\right) 63.6\ \%$; ***[2]***
Accept alternative calculation method.

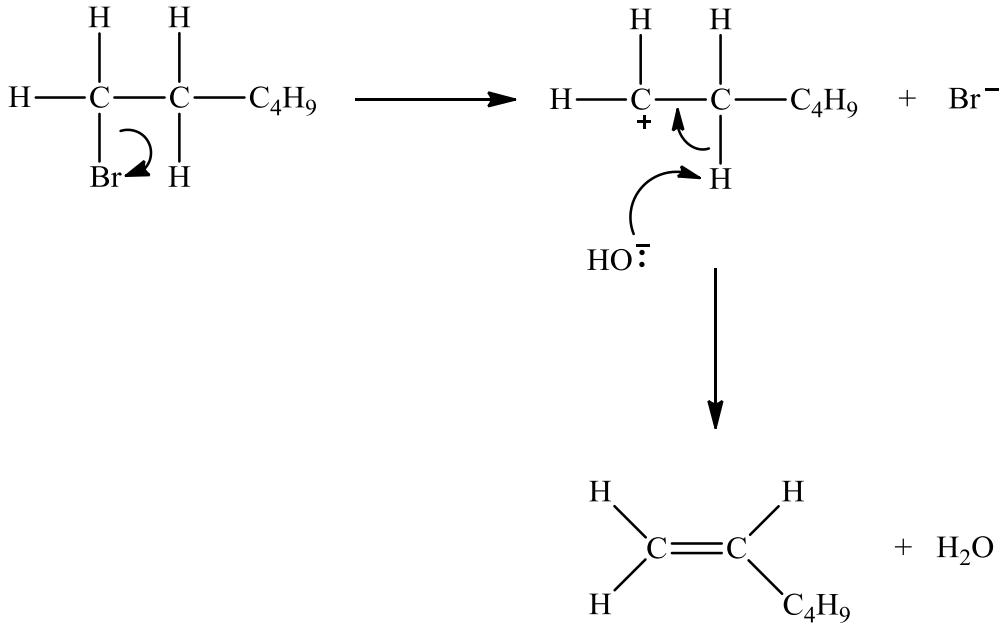
(iii) yield above 100% not possible / experimental yield > theoretical yield / *OWTTE*;
Must have reference to a final yield.

sample contaminated with hexan-1-ol/water / inadequate drying / *OWTTE*; ***[2]***
Do not accept error in reading balance/weighing scale.

(b)



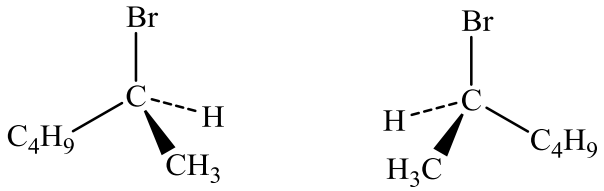
OR



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

curly arrow going from CH bond to form C=C bond;
curly arrow showing Br leaving;
formation of organic product $H_2C{=}CH(C_4H_9)$ **and** H_2O **and** Br^-; ***[4]***

(c) (i)



[2]

(ii) use a polarimeter / polarimetry;
isomers rotate <u>plane</u> of polarized light in <u>equal</u>, but opposite directions; ***[2]***

(d) geometric / cis-trans / E-Z; ***[1]***

(e) (i) 2-methylpentane;
3-methylpentane;
2,2-dimethylbutane;
2,3-dimethylbutane; ***[3 max]***

(ii) hexane;
Accept the molecular structure, full structural formula or condensed structural formula.

straight chain/no branches, hence increased surface area/more closely packed;
stronger/larger/greater London/dispersion/van der Waals'; ***[3]***
Accept the opposite arguments.
Do not accept stronger/larger/greater intermolecular forces.

(f) *Initiation:*
$Cl_2 \rightarrow 2Cl\bullet$;

Essential condition:
UV/sunlight/*hf*/*hν*;

Propagation:
$Cl\bullet + R\text{–}H \rightarrow HCl + R\bullet$ / $R\bullet + Cl_2 \rightarrow RCl + Cl\bullet$;

Termination:
$Cl\bullet + Cl\bullet \rightarrow Cl_2$ / $Cl\bullet + R\bullet \rightarrow RCl$ / $R\bullet + R\bullet \rightarrow R_2$; ***[4]***
Allow more specific detail of R based on hexane (e.g. $CH_3(CH_2)_4CH_2$–H) in mechanistic steps.

8. (a) (i) ionization, acceleration, deflection/separation
*Award **[1]** for all three names and **[1]** for correct order.*
*Award **[1]** for two names in correct order.*

Ionization:
sample bombarded with (high-energy/high-speed) electrons / *OWTTE*;
Acceleration:
electric field/oppositely charged plates;
Deflection:
(electro)magnet/magnetic field; ***[5]***

(ii) ratio of average/mean mass of an atom to the mass of C-12 isotope / average/mean mass of an atom on a scale where one atom of C-12 has a mass of 12 / sum of the weighted average/mean mass of isotopes of an element compared to C-12 / *OWTTE*; ***[1]***
Award no mark if "element" is used instead of "atom".

(iii) $A_r = \frac{(46\times13.5)+(47\times7.4)+(48\times73.7)+(49\times5.4)}{100}$;
47.7; ***[2]***
*Accept atomic mass units but award **[1 max]** if other units given.*
Answer must be given to one decimal place.

(iv) prevents collisions/unintentional deflections */ OWTTE*; ***[1]***

(b) (i) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^2$;
4s; ***[2]***

(ii) 4^{th} electron removed from 3d **and** 5^{th} electron removed from 3p;
10^{th} electron removed from 3p **and** 11^{th} electron removed from 3s;

Accept either of the following answers for the third mark:
electrons removed from lower energy level / energy level closer to nucleus are attracted more strongly;
greater effective nuclear charge / s electrons more penetrating; ***[3 max]***

(iii) +2, +3, +4; ***[1]***

(iv) (colour) due to partially filled/incomplete d sub-level/orbital;
d sub-level is split / d orbitals are split;
$Ni^{2+}(aq)$ has incomplete 3d sub-level/orbital but $Sc^{3+}(aq)$ has no 3d electron/empty/d sub-level;
electrons move from lower to higher (sub)levels when they absorb energy/light;
$Ni^{2+}(aq)$ (appears green because it) absorbs red; ***[5]***

(c) (i) line spectrum;
(lines) converge at high energy/frequency/shorter wave length/blue end of spectrum; ***[2]***
Both marks can be awarded if suitable diagram is given.

(ii) electron transition from higher to lower/second energy levels;
each transition causes emission of light of specific frequency/wavelength/energy;
each transition/line is related to energy difference / $\Delta E = \frac{hf \ / h\nu / hc}{\lambda}$;
energy levels in hydrogen atom are closer/converge at higher energy; ***[3 max]***