IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

MARKSCHEME

November 2005

CHEMISTRY

Standard Level

Paper 2

10 pages

http://www.xtremepapers.net

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Subject Details: Chemistry SL Paper 2 Markscheme

General

- Each marking point has a separate line and the end is signified by means of a semicolon (;).
- Alternative answers are separated by a slash (/) – this means that either answer is acceptable.
- Words underlined are essential for the mark.
- Material in brackets (…) is not needed for the mark.
- The order in which candidates score marks does not matter (unless stated otherwise).
- The use of ***OWTTE*** in a markscheme (the abbreviation for "or words to that effect") means that if a candidate's answer contains words different to those in the markscheme, but which can be interpreted as having the same meaning, then the mark should be awarded.
- Please remember that many candidates are writing in a second language, and that effective communication is more important than grammatical accuracy.
- In some cases there may be more acceptable ways of scoring marks than the total mark for the question part. In these cases, tick each correct point, and if the total number of ticks is greater than the maximum possible total then write the maximum total followed by **MAX**.
- In some questions an answer to a question part has to be used in later parts. If an error is made in the first part then it should be penalized. However, if the incorrect answer is used correctly in later parts then "follow through" marks can be scored. Show this by writing **ECF** (error carried forward). This situation often occurs in calculations but may do so in other questions.
- Units for quantities should always be given where appropriate. In some cases a mark is available in the markscheme for writing the correct unit. In other cases the markscheme may state that units are to be ignored. Where this is not the case, penalize the omission of units, or the use of incorrect units, once only in the paper, and show this by writing **−1(U)** at the first point at which it occurs.
- Do not penalize candidates for using too many significant figures in answers to calculations, unless the question specifically states the number of significant figures required. If a candidate gives an answer to fewer significant figures than the answer shown in the markscheme, penalize this once only in the paper, and show this by writing **−1(SF)** at the first point at which this occurs.
- If a question specifically asks for the name of a substance, do not award a mark for a correct formula; similarly, if the formula is specifically asked for, do not award a mark for a correct name.
- 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 the question specifically asks for this. In some cases, where more complicated equations are to be written, more than one mark may be available for an equation – in these cases follow the instructions in the mark scheme.
- Ignore missing or incorrect state symbols in an equation unless these are specifically asked for in the question.
- Mark positively. Give candidates credit for what they have got correct, rather than penalizing them for what they have got wrong.
- If candidates answer a question correctly, but by using a method different from that shown in the markscheme, then award marks; if in doubt consult your Team Leader.

SECTION A

1. (a) % of oxygen = 36.4;

$C = \frac{54.5}{12.01}, H = \frac{9.1}{1.01}, O = \frac{36.4}{16.00}$;

Do not penalize the if 12, 1 and 16 are used.

C_2H_4O; ***[3]***

If atomic numbers or incorrect A_r values used, only first mark can be scored.
*Award **[3]** for correct formula without working.*

(b) $pV = nRT$ / $pV = \frac{mRT}{M_r}$/correct rearrangement;

$M_r = \frac{0.230 \times 8.31 \times 368}{102 \times 10^3 \times 0.0785 \times 10^{-3}}$;

*Award **[1]** for 368 even if incorrect expression given.*

$M_r = 87.8$; ***[3]***

Accept answer in range 87.8 to 88.
Do not allow ECF.
*Award **[3]** for correct final answer.*

(c) $C_4H_8O_2$; ***[1]***

Answer does not need to show working to receive the mark.
Do not allow ECF.

(d) (i) 2-methylbutanoic acid; ***[1]***
Do not accept 3-methylbutanoic acid.

(ii) yes, because of chiral centre/carbon with four different groups; ***[1]***

2. (a) increase in product concentration per unit time/decrease in reactant concentration per unit time; ***[1]***
Accept change instead of increase or decrease.

(b) (i) high activation energy/not enough molecules have E_a/*OWTTE*;
incorrect collision geometry/*OWTTE*;
infrequent collisions; ***[2 max]***
*Award **[1]** for any two reasons.*

(ii) more energetic collisions / more molecules have (energy ≥) E_a;
more <u>frequent</u> collisions / collide more often; ***[2]***

(iii) add a catalyst;
increase the (total) pressure / decrease the volume of the container;
increase the concentration of C (or D); ***[2 max]***
Do not accept surface area.
*Award **[1]** for any two.*

3. (a)

	an atom of ^{79}Br	an ion of $^{81}Br^-$	
protons	35	35	;
neutrons	44	46	;
electrons	35	36	;

[3]

(b) ^{79}Br because A_r is closer to 79 / *OWTTE*; ***[1]***

(c) (i) 2,8,8,2 / 2.8.8.2; ***[1]***

(ii) $CaBr_2$; ***[1]***

4. (a) (i) the (minimum) energy required/needed for the removal of one electron;
from a gaseous/isolated atom; ***[2]***

(ii) $Al(g) \rightarrow Al^+(g) + e$; ***[1]***
Do not penalize the answer if (g) is after e.

(b) greater nuclear charge / greater number of protons / atom radius g is smaller;
stronger attraction (for electron); ***[2]***

(c) $2Li + 2H_2O \rightarrow 2LiOH + H_2$;
Ignore state symbols.

effervescence/fizzing/bubbles/*OWTTE*;
lithium moves around/decrease in size of piece;
Accept dissolves or disappears.
heat produced; ***[3 max]***
*Award **[1]** each for any two of last three observations.*

SECTION B

5. (a) (i) standard enthalpy (change) of reaction;
(temperature) increase;
reaction is exothermic/sign of ΔH° is negative; ***[3]***

(ii) more (negative);
heat given out when gas changes to solid/solid has less enthalpy than gas/*OWTTE*; ***[2]***

(iii) –389 kJ; ***[1]***

(iv) negative;
fewer gas particles/decrease in gas moles;
decrease in entropy/increase in order/decrease in disorder; ***[3]***

(b) (i) the energy needed to break one bond;
(in a molecule in the) gaseous state;
value averaged using those from similar compounds; ***[3]***

(ii) it is an element/no other species with just a Br-Br bond/*OWTTE*; ***[1]***

(iii) (sum bonds broken =) 412 + 193 = 605;
(sum bonds formed =) 276 + 366 = 642;
$(\Delta H^\ominus =) -37$ kJ; ***[3]***
*Award **[3]** for correct final answer.*
*Award **[2]** for "+ 37".*
Accept answer based on breaking and making extra C-H bonds.

(iv)

Enthalpy | $CH_4 + Br_2$; $CH_3Br + HBr$ ***[2]***

*Award **[1]** for enthalpy label and two horizontal lines, **[1]** for reactants higher than products.*
ECF from sign in (iii), ignore any higher energy level involving atoms.

(v) (about) the same/similar;
same (number and type of) bonds being broken and formed; ***[2]***

6. (a) (i) $(K_c =) \frac{[NO_2]^2}{[N_2O_4]}$;
(horizontal line) concentration of reactant and product remains constant / equilibrium reached;
(magnitude of) K_c greater than 1;
Accept 1.6.
product concentration greater than reactant concentration; ***[4]***

(ii) increased temperature shifts equilibrium position to right;
(forward) reaction is endothermic / absorbs heat; ***[2]***

(iii) increased pressure shifts equilibrium to left;
fewer (gas) moles/molecules on left; ***[2]***

(iv) both/forward and reverse rates increased / increase in forward reverse rates are equal;
activation energy reduced;
position of equilibrium unchanged;
concentration/amount of reactants and products remain constant;
value of K_c unchanged;
K_c only affected by changes in temperature; ***[6]***

(b) (i) X; ***[1]***

(ii) greater in Y/smaller in Z;
by a factor of 10; ***[2]***

(iii) Y > Z > X;
most ions/greatest concentration of ions in Y/*OWTTE*; ***[2]***

(iv) sodium hydroxide/sodium salt of X; ***[1]***
Accept formula.

7. (a) same general formula/C_nH_{2n};
formulas of successive members differ by CH_2;
similar chemical properties/same functional group;
gradation/gradual change in physical properties; ***[3 max]***
*Award **[1]** each for any three.*

(b) but-2-ene;
Accept 2-butene.

strongest intermolecular/van der Waals' forces;
largest (molecular) mass/size/surface area/area of contact; ***[3]***

(c) $CH_2CHCH_2CH_2CH_3$/$CH_3CHCHCH_2CH_3$/any correct branched structure;
Accept more detailed formula.

pent-1-ene/pent-2-ene; ***[2]***
Name must match formula.
Accept 1-pentene / 2-pentene.

(d) $C_4H_8 + HBr \rightarrow CH_3CH_2CHBrCH_3$;
*Award **[1]** for all molecular formulas correct and **[1]** for correct product structure.*
*Award **[1]** for completely correct equation starting with but-1-ene.*

addition; ***[3]***

(e) oxidation / redox;
(potassium) dichromate(VI) / $Cr_2O_7^{2-}$;
(sulfuric) acid;
distilling off propanal as it is formed;
heating under reflux (to obtain propanoic acid); ***[5]***

(f) (propan-1-ol) hydrogen bonding;
(propanal) dipole-dipole attractions;
(propanoic acid) hydrogen bonding;
propanoic acid > propan-1-ol > propanal; ***[4]***