International Baccalaureate
Baccalauréat International
Bachillerato Internacional

MARKSCHEME

May 2008

CHEMISTRY

Higher Level

Paper 3

*This markscheme is **confidential** and for the exclusive use of examiners in this examination session.*

*It is the property of the International Baccalaureate and must **not** be reproduced or distributed to any other person without the authorization of IB Cardiff.*

Subject Details: Chemistry HL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options **[2 x 25 marks]**. Maximum total = **[50 marks]**

1. A markscheme often has more marking points than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified 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.

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 writing ***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. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the mark scheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by writing –**1(SD)** at the first point it occurs and **SD** on the cover page.

12. 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.

13. 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.

14. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option B – Medicines and drugs

B1. (a) $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$;
$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$; *[2]*
*Award **[1 max]** if H_2CO_3 given as the product.*

(b) twice as much HCl neutralized / *OWTTE*; *[1]*

(c) to prevent stomach acid rising (into the esophagus) / to prevent heartburn / to prevent acid reflux; *[1]*

(d) (i) carbon dioxide (gas) produced (in both reactions); *[1]*

(ii) MgO / $Mg(OH)_2$ / $Al(OH)_3$; *[1]*
Accept correct name in place of formula.

B2. (a) liver damage / liver disease / liver cancer / cirrhosis;
increased blood pressure / heart disease / stroke;
miscarriage / fetal abnormalities; *[2 max]*
*Award **[1]** each for any two.*

(b) potassium dichromate / $K_2Cr_2O_7$ / $Cr_2O_7^{2-}$;
orange to green;
ethanal / CH_3CHO / ethanoic acid / CH_3COOH; *[3]*

B3. (a) 16; *[1]*

(b) (i) penicillin G deactivated by penicillinase/enzyme; *[1]*

(ii) side chain/R group modified/rearranged / *OWTTE*; *[1]*

(c) cell wall formation prevented / cell wall destroyed; *[1]*

(d) (i) takes/analyses sample (of blood, urine, *etc.*) / identifies bacterium; *[1]*

(ii) kills beneficial/useful bacteria; *[1]*
Do not accept good or friendly bacteria.

B4. (a) (i) benzene / aromatic ring / phenyl; ***[1]***

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

(iii) ester; ***[1]***

(b) (i) A **and** C; ***[1]***

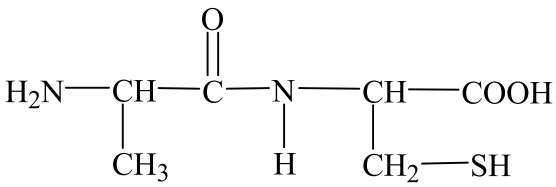
(ii) D / B; ***[1]***

(c) total moles $= 2.0 / 2$;
mole fraction of halothane $= 0.1 \div 2.0 / 0.05$;
Apply ECF from incorrect total moles, ignore any units.

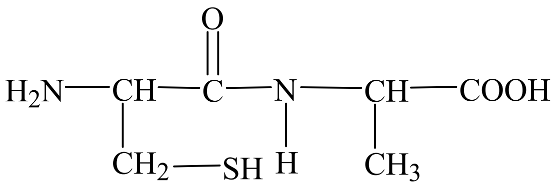
pp halothane $= 120 \times 0.05 = 6$ (kPa); ***[3]***
*Correct final answer scores **[3]**.*
Apply ECF from incorrect mole fraction.
Units not needed for mark, but penalise incorrect units.

Option C – Human biochemistry

C1. (a)



;



; ***[2]***

(b) condensation;
water / H_2O; ***[2]***

(c) (i) hydrolyses polypeptide/protein / releases amino acids; ***[1]***

(ii) place amino acid mixture on gel/paper;
use buffer solution;
apply potential difference;
acids move different distances;
develop/spray with ninhydrin;
compare isoelectric points / compare distances travelled with standards; ***[4 max]***
*Award **[1]** each for any four.*

C2. (a) (i) $CH_3(CH_2)_{20}COOH$ / other correct more detailed formula; ***[1]***

(ii) 340 / 341; ***[1]***

(b) erucic acid has kinked chain / *OWTTE*;
molecules pack less closely / reduces area of contact;
van der Waals'/intermolecular/London/dispersion forces weaker; ***[3]***
Do not accept weaker hydrogen bonding.
Accept opposite arguments for behenic acid.
If answers refer to the relative strengths or the breaking of C–C or C=C bonds, then no marks can be awarded.

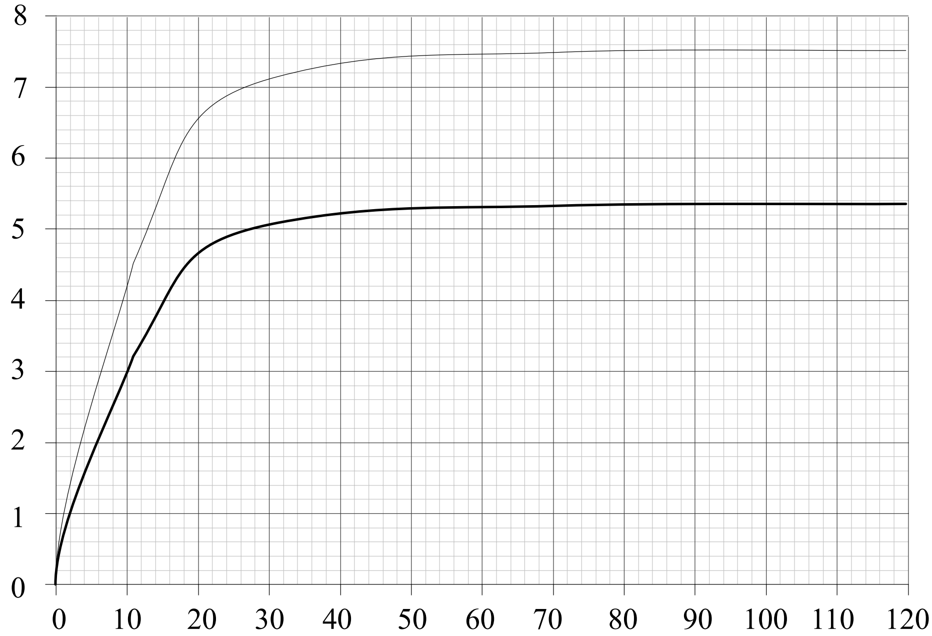
(c) number $= \dfrac{304 \times 334}{254 \times 100}$ / other correct working;
= 4; ***[2]***
*Award **[1]** for final answer of 8 based on use of A_r instead of M_r of iodine.*

C3. pentose sugar/deoxyribose and phosphate;
adenine-thymine and cytosine-guanine;
Accept A–T and C–G.

hydrogen bonding;
two in A–T and three in C–G; ***[4]***

C4. (a) $V_{max} = 7.6\ (10^{-9}\ \text{mol dm}^{-3}\ \text{min}^{-1})$;
$K_m = 8.4 - 9.0\ (10^{-6}\ \text{mol dm}^{-3})$; ***[2]***

(b) curve on graph levelling off below original line; ***[1]***
e.g.



(c) it binds to E but not at active site;
E changes shape (so S cannot bind to E); ***[2]***

Option D – Environmental chemistry

D1. (a) $N_2 + O_2 \rightarrow 2NO$; ***[1]***

(b) $2H_2S + 3O_2 \rightarrow 2SO_2 + 2H_2O$; ***[1]***

(c) respiratory irritant / causes respiratory tract infections; ***[1]***

(d) $2NO + 2CO \rightarrow N_2 + 2CO_2$; ***[1]***

(e) (particulates) attracted to oppositely charged electrodes / electrostatic precipitation; ***[1]***

D2. (a) (i) (N_2O) more effective / better at trapping heat; ***[1]***

(ii) (CO_2) more abundant; ***[1]***

(b) radiation/energy from sun is short wavelength;
absorbed by (surface of) earth;
radiation emitted by earth is long(er) wavelength;
greenhouse gases absorb this radiation;
(which is) (re-)radiated back to earth;
*Award **[1]** each for any three up to **[3 max]**.*

climate change / stated example such as desertification;
global warming;
melting of glaciers/ice caps;
coastal flooding / rise in sea level; ***[4 max]***
*Award **[1]** for any of the above four.*

D3. ozone more expensive because it must be generated on site / chlorine cheaper because it can be stored on site / *OWTTE*;
effect of chlorine lasts longer / effect of ozone lasts for shorter time;
both kill bacteria / only ozone effective against viruses;
chlorine leaves taste / ozone does not leave taste;
chlorine produces toxic/carcinogenic products / ozone does not; ***[4 max]***
*Award **[1]** each for any two of last three points.*

D4. 1 $HO_2\bullet + NO \rightarrow HO\bullet + NO_2$;

2 $HO\bullet + RCH_3 \rightarrow RCH_2\bullet + H_2O$;

3 $RCH_2\bullet + O_2 \rightarrow RCH_2O_2\bullet$;

4 $RCH_2O_2\bullet + NO \rightarrow RCH_2O + NO_2$;

5 $RCH_2O\bullet + O_2 \rightarrow RCHO + HO_2\bullet$; ***[5]***

Penalise missing • symbol once only.

D5.

(metal)	*(sources)*	*(health effect)*
(cadmium)	metal plating;	vomiting / stomach pains;
	zinc mining;	kidney/lung cancer;
	paints / pigments;	brittle bones;
	(rechargeable) batteries;	Itai-Itai disease;
	*Award **[1]** each for any two.*	*Award **[1]** for one of the above.*
(mercury)	fungicides / seed dressings;	
	electrolysis of brine / chloralkali industry;	
	(tooth) fillings;	***[5 max]***
	*Award **[1]** each for any two.*	
	No credit for mercury thermometer or battery.	

Option E – Chemical industries

E1. (a) (i) $2CH_4 + O_2 \rightarrow 2CO + 4H_2$ / $CH_4 + \frac{1}{2}O_2 \rightarrow CO + 2H_2$; ***[1]***

(ii) $Fe_3O_4 + H_2 \rightarrow 3FeO + H_2O$; ***[1]***

(iii) $FeO + CO \rightarrow Fe + CO_2$; ***[1]***

(b) (i) becomes less brittle/more malleable; ***[1]***

(ii) acid-base reaction / neutralization; ***[1]***

E2. (a) lowers operating temperature/melting point of alumina/mixture/ acts as solvent; ***[1]***
Do not accept "lowers melting point of aluminium".

(b) *Positive electrode:*
$2O^{2-} \rightarrow O_2 + 4e^-$;

Negative electrode:
$Al^{3+} + 3e^- \rightarrow Al$; ***[2]***
Accept $-4e^-$ *on LHS of first equation.*
*Award **[1]** if both equations correct but at wrong electrodes.*

(c) carbon / graphite / C;
burn in oxygen / react with oxygen / form carbon dioxide; ***[2]***
Do not accept erode/corrode/wear away.

E3. (a) column hotter at the bottom/cooler at the top;
molecules/fractions with lower boiling points/smaller sizes rise higher;
fractions condense at different heights; ***[3]***

(b) $C_7H_{16} \rightarrow 2C_2H_4 + C_3H_8$; ***[1]***

(c) $C_6H_{14} \rightarrow C_6H_{12} + H_2$; ***[1]***

E4. *species:*
(LDPE) (free) radicals and *(HDPE)* ions;

branching:
(LDPE) (more) branching / *(HDPE)* no/little branching;

forces:
van der Waals' / London / dispersion (in both);
weaker in LDPE / stronger in HDPE; ***[4]***

E5. (a) (A) brine / sodium chloride (solution) / $NaCl(aq)$;
(B) chlorine / Cl_2;
(C) hydrogen / H_2;
(D) sodium hydroxide (solution) / $NaOH(aq)$; ***[4]***
*Award **[1]** for both chlorine and hydrogen the wrong way round.*

(b) *positive electrode:*
$2Cl^- \rightarrow Cl_2 + 2e^-$;

negative electrode:
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ / $2H^+ + 2e^- \rightarrow H_2$; ***[2]***

Accept balancing using any coefficients, and $-2e^-$ *on RHS of equation at – electrode.*
Ignore state symbols.

Option F – Fuels and energy

F1. (a) (C) $(394 \div 12) = 32.8\,(\text{kJ g}^{-1})$;
(CH_4) $(890 \div 16) = 55.6\,(\text{kJ g}^{-1})$;
(C_8H_{18}) $(5512 \div 114) = 48.4\,(\text{kJ g}^{-1})$; ***[3]***
No penalty for use of negative signs.
Accept use of A_r values as integers or to 2 dp.
If atomic number used instead of atomic mass, penalise once only.

(b) $C + H_2O \rightarrow CO + H_2$; ***[1]***

F2. (a) ${}^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{90}_{36}Kr + 2\,{}^{1}_{0}n$ ***[2]***
*Award **[1]** for all three isotopes correct.*
*Award **[1]** for two neutrons formed.*

(b) (i) time for amount/mass of isotope/activity of sample to halve / *OWTTE*; ***[1]***

(ii) (2 hours is) 6 half-lives;
2 (mg) / 0.002 g; ***[2]***
No credit for 2 g

(iii) Tl;
Po; ***[2]***

(iv) alpha deflected less / beta deflected more;
alpha moves towards negative / beta moves towards positive / alpha and beta deflected in opposite directions; ***[2]***

F3. (a) $PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$;
Accept H_2SO_4 + $2H^+$ on LHS.

$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$; ***[2]***
Accept use of $-2e^-$ on opposite sides.

(b) (i) voltage depends on nature of materials used / *OWTTE*; ***[1]***

(ii) <u>six</u> connected together (in series); ***[1]***

F4. mass loss $= 235.0943 - (147.9322 + 84.9165 + 2 \times 1.0087) / 0.2282\,\text{g}$;
$= 2.282 \times 10^{-4}\,\text{kg}$;
Apply ECF to incorrect number of neutrons.

$E = mc^2 = 2.282 \times 10^{-4} \times (3.00 \times 10^8)^2$;
$= 2.05 \times 10^{13}\,(\text{J})$; ***[4]***
Apply ECF from incorrect mass loss.

F5. arsenic provides an (extra) electron;
gallium produces an electron hole/shortage;
sunlight/photons cause electrons to be released;
voltage or potential difference formed;
electrons flow from n- to p-type material/layer / through external circuit; ***[4 max]***
*Any four for **[1]** each.*

Option G – Modern analytical chemistry

G1. (a) (i) (P) ultraviolet/uv **and** (Q) infrared/ir; ***[1]***

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

(b) mass spectrometry/spectroscopy; ***[1]***

(c) (i) (only) HBr has (atoms with) different electronegativities / (only) H–Br is polar / O_2 is non-polar;
No credit just for saying atoms are different.

(only) HBr changes dipole moment/bond polarity; ***[2]***

(ii) molecule can bend/change shape / deform / change its bond angle; ***[1]***

G2. (a) (i) 1000-1300 (cm^{-1}) **and** 1680-1750 (cm^{-1}); ***[1]***

(ii) 2500-3300 (cm^{-1}); ***[1]***

(iii) $CH_2{=}CH{-}CH(OH){-}O{-}CH_3$;

Accept any correct structure of $C_4H_8O_2$ with $C{=}C$. ***[1]***

(b) *number of peaks:*
number of different types of hydrogen/proton / number of different hydrogen/proton environments;

ratio of areas:
(relative) numbers of hydrogens/protons in each environment;

splitting pattern:
number of hydrogens/protons attached to neighbouring carbon; ***[3]***

(c)

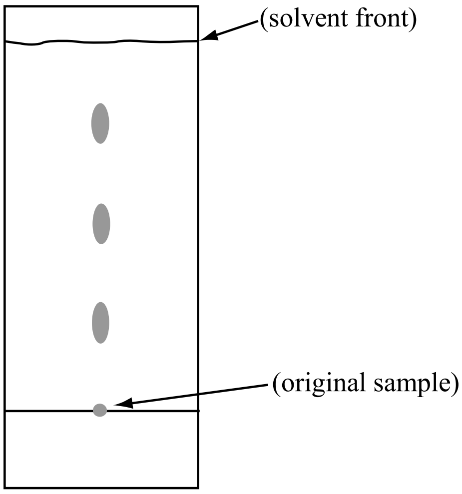
(B ratio)	3:3:2 *(any order)*;
(B splitting pattern)	1 singlet + 1 triplet + 1 quartet;
(C ratio)	6:1:1 *(any order)*;
(C splitting pattern)	1 singlet + 1 doublet + 1 quartet/septet; ***[4]***

If B splitting pattern given as 1,3,4 (any order) do not award mark but use ECF and award mark for C splitting pattern if given as 1,2,7/4 (any order).

(d) (peaks with) different δ values/chemical shifts / different shielding; ***[1]***
Do not accept 'different ppm values'

(e) $CH_3{-}CH_2{-}C({=}O){-}O{-}CH_3$; ***[1]***

G3. (a) reasonable diagram showing three distinct components above original sample mark;
e.g.



(stationary phase) water in structure of paper that does not move;
Do not accept just paper.

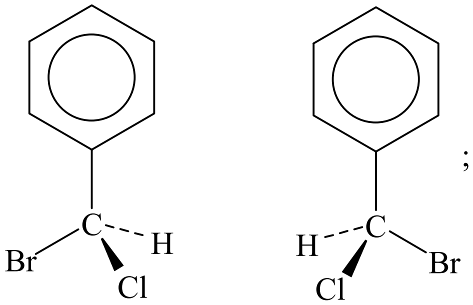
(mobile phase) water/solvent that moves up paper;
(solvent front) distance travelled by solvent at end of experiment;
(R_f value) distance moved by dye ÷ distance moved by solvent; ***[5]***

(b) (paper) partition;
(column) adsorption;
(gas-liquid) partition; ***[2 max]***
*Award **[2]** for three correct, **[1]** for two correct, **[0]** for one or none correct.*

Option H – Further organic chemistry

H1. (a) **C** and **D**;
H; *[2]*

(b) (i)



Diagrams must display 3d structures. *[1]*

(ii) plane-polarized light;
rotated in opposite directions / one rotates to the left and one to the right; *[2]*
Do not accept bent / refracted / reflected.
Do not accept d- and l- forms on their own without reference to different rotation.

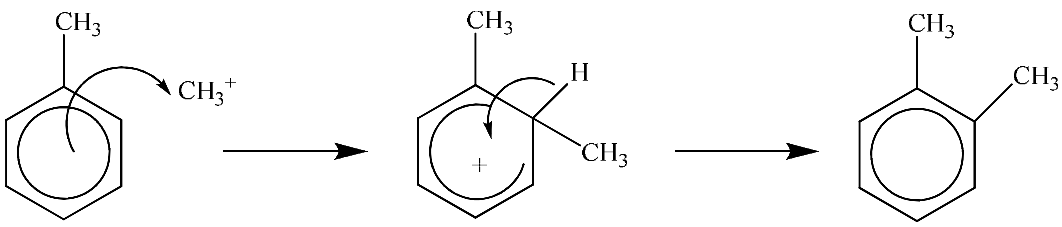
(iii) equimolar mixture (of both isomers) / *OWTTE*; *[1]*
Not just both isomers present.

(c) (i) **E** because of stronger intermolecular forces / hydrogen bonding;
E has intermolecular hydrogen bonding;
F has intramolecular hydrogen bonding; *[3]*
Award 2nd and 3rd marks even if F chosen as higher melting point.

(ii) F because COOH groups closer together;
can lose water / forms anhydride; *[2]*

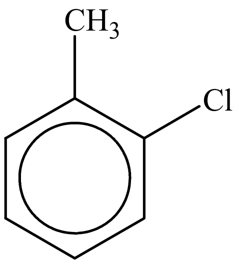
(d) CH_3Cl / CH_3Br reagent;
$CH_3Cl + AlCl_3 \rightarrow CH_3^+ + AlCl_4^-$ *(curly arrows not needed for this step)*;
curly arrow from circle in benzene to CH_3^+;
structure of and charge on carbocation;
curly arrow showing loss of H^+; *[5]*
Ignore anything after this step.

e.g.

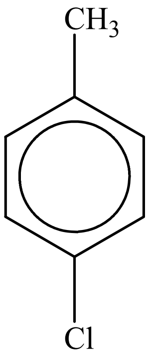


(e) (i) because CH_3 electron-releasing/has (positive) inductive effect;
makes benzene more electron-rich/susceptible to attack by electrophile/ CH_3^+; ***[2]***

(ii)



;



; ***[2]***

H2. (a) methanoic acid stronger because ethanoic acid has electron – releasing methyl group;
chloroethanoic acid stronger because of electron – withdrawing Cl;
chloroethanoic acid stronger because Cl is more electron – withdrawing than I; ***[3]***
Accept opposite arguments for other acid of each pair.
*If all three acids correctly identified, but all explanations missing or incomplete award **[1]**.*

(b) (pK_a values)
butanoic acid > 4-chlorobutanoic acid > 2-chlorobutanoic acid;

OR

(acid strengths)
2-chlorobutanoic acid > 4-chlorobutanoic acid > butanoic acid;

Cl less effective when further away from COOH group; ***[2]***