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

N07/4/CHEMI/HP3/ENG/TZ0/XX/M+

MARKSCHEME

November 2007

CHEMISTRY

Higher Level

Paper 3

19 pages

Subject Details: Chemistry HL Paper 3 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 that are <u>underlined</u> 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.

Option B – Medicines and drugs

B1. (a) hydrochloric acid / HC1; ***[1]***

(b) $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$;
$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$; ***[2]***
Accept equations with H^+ instead of HCl / OH^- instead of $Mg(OH)_2$ and HCO_3^- instead of $NaHCO_3$.

(c) $Al(OH)_3$;
neutralize 0.03 mol of H^+ / contains three OH^- ions / *OWTTE*; ***[2]***
Do not award second mark if other than $Al(OH)_3$ chosen

B2. (a) *mild analgesics*
they prevent/interfere with the production of substances/prostaglandins that cause pain;
they intercept pain at its source;

strong analgesics
they bond to receptor sites in the brain;
pain signals within brain/spinal cord blocked; ***[4]***

(b) (i) CH_3CO ; ***[1]***
Accept $COCH_3$ but not CH_3COO

(ii) *acetaminophen (paracetamol)*
amide;
hydroxy(l) / phenol / alcohol;

ibuprofen
carboxylic acid;
Do not accept carboxyl
Ignore any formulae even if wrong ***[3]***

(iii) ibuprofen;
asymmetric/chiral carbon atom / carbon atom joined to four different groups; ***[2]***
Award second mark even if ibuprofen not chosen

B3. (a)

	N_2O ;	
cyclopropane;		
halothane / 2-bromo-2-chloro-1,1,1-trifluoroethane;		

[3]

Accept 1-bromo-1-chloro-2,2,2-trifluoroethane.
Do not penalise missing commas and hyphens, or commas used instead of hyphens, but the numbers must be right if they choose this alternative.

(b) (i) 3:1:2; ***[1]***
If numbers are in a different order, e.g. 1:2:3, the answer needs to indicate which number refers to which gas.

(ii) (total pressure =) 108 kPa;
Award mark if unit missing but penalise incorrect unit
(% of oxygen =) 33(.3); ***[2]***
Apply ECF from incorrect total pressure, e.g. $36 \times 100 \div 72 = 50\ \%$

B4. *arguments for*
relieves symptoms of cancer/AIDS/glaucoma/Parkinson’s disease;
reduction of crime;
matter of individual freedom;

arguments against
causes respiratory ailments/heart disease/cancer / suppresses immune system;
increases risk of trying more damaging/harder drugs;
reduces ability to drive/operate machinery safely; ***[4 max]***
Award ***[1]*** *for any four arguments, minimum one for and one against*

Option C – Human biochemistry

C1. (a) $\Delta T = 65.1 - 18.3 = 46.8$ (°C or K);
heat produced $(= mc\Delta T) = 400 \times 4.18 \times 46.8$;
Mark is for substitution of three values
ECF from temperature rise

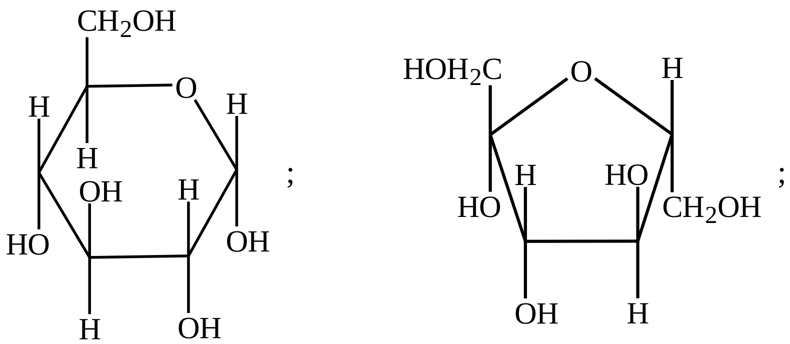
$= 78\,249.6$ J / 78.2496 kJ;
Mark is for correct answer in J or kJ, with 3 or more sig fig

= 1565 (kJ per 100g); ***[4]***
Allow answers in the range of 1560-1600
Mark is for conversion to correct unit

(b) $n(I_2) = \frac{5}{253.8} = 0.0197$;
2 (double bonds); ***[2]***

C2. (a) glycosidic / glucoside / ether; ***[1]***

(b)



[2]

Do not penalise candidates who draw bonds connected to the incorrect atom – e.g. –HO instead of –OH

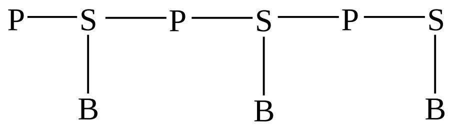
(c) CH_2O; ***[1]***

C3. (a) vitamin C / ascorbic acid;
four/many OH groups / small proportion of hydrocarbon / can form hydrogen bonds with water / *OWTTE*; ***[2]***

(b) vitamins A/retinol and C/ascorbic acid; ***[1]***

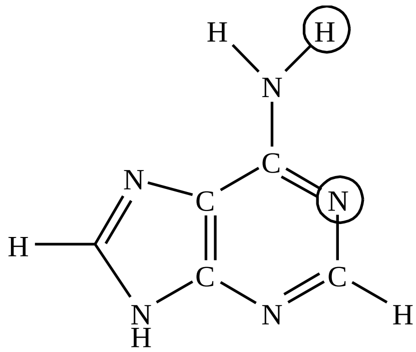
(c) needed for uptake of calcium/phosphate;
bone problem such as softening/weakness/malformation / rickets; ***[2]***

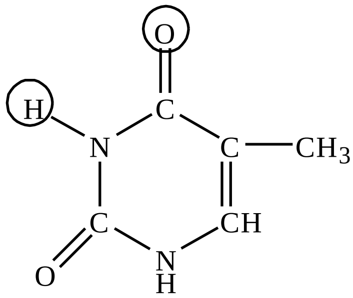
C4. (a)



three alternate P and S;
three S–B bonds; ***[2]***

(b)





correct N and H in adenine circled;

structure of thymine;
correct O and H in thymine circled; ***[3]***

C5. $[K^+]$ naturally higher inside cell / $[Na^+]$ naturally higher outside cell;
concentrations tend to equalize through osmosis/diffusion;
K^+ pumped into cell / Na^+ pumped out of cell;
protein Na-K-ATPase (in cell wall);
changes shape (during pumping);
K^+ passes more easily because of larger size/lower charge density; ***[5 max]***
*Award **[1]** for any five*

Option D – Environmental chemistry

D1. (a) carbon monoxide / CO;
(unburned) hydrocarbons;
$2CO + 2NO \rightarrow 2CO_2 + N_2$; ***[3]***

(b) $2CO + O_2 \rightarrow 2CO_2$; ***[1]***

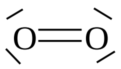
D2. (a) ultra-violet / uv;

(increased) skin cancer;
(eye) cataracts;
suppression of plant growth/photosynthesis; ***[3 max]***
*Award **[1]** each for any two effects*

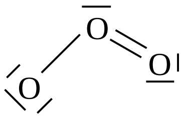
(b) $O_3 \rightarrow O_2 + O\bullet$;
$O_3 + O\bullet \rightarrow 2O_2$; ***[2]***
No penalty for missing radical symbols

D3. *Award **[1]** for each of the following in order.*
*Primary**:*** filtration / screening;
Secondary: aeration / activated sludge (process);
Tertiary: (chemical) precipitation;
Material removed in secondary: organic matter;
Substances used in tertiary:
hydrogen sulfide / calcium hydroxide / sodium carbonate;
aluminium sulfate / calcium (hydr)oxide / Al^{3+} ions / Ca^{2+}; ***[6]***
Accept correct formulae in place of names
Do not accept names or symbols of metals, e.g. calcium, Al

D4. (a) *oxygen*

 ;

ozone

 ;

Electron pairs can also be shown by dots and/or crosses
any value between 146 and 496 (kJ mol^{-});
average of 146 and 496 / intermediate between single and double bond; ***[4]***

(b) absorbs ultraviolet / UV radiation from the sun;
alternate/conjugated (C=C) double bonds; ***[2]***

D5. *sources*
fungicides / seed dressings;
batteries;
electrolysis of brine / manufacture of chorine/sodium hydroxide;
dental amalgams;
*Award **[1]** each for any two*

effects
Minamata disease;
mental disorders / brain damage;
kidney/liver damage; ***[4 max]***
*Award **[1]** each for any two*

Option E – Chemical industries

E1. (a) rock is crushed/powdered;
mixed with water and oil;
air blown through;
Do not accept oxygen

galena/lead sulfide/PbS sticks to oil;
floats to top of liquid; ***[3 max]***
*Award **[1]** each for any three*

(b) (i) $2PbS + 3O_2 \rightarrow 2PbO + 2SO_2$; ***[1]***

(ii) sulfuric acid / H_2SO_4; ***[1]***

(c) (i) reduction; ***[1]***

(ii) $PbO + C \rightarrow Pb + CO$;
$2PbO + C \rightarrow 2Pb + CO_2$;
$PbO + CO \rightarrow Pb + CO_2$; ***[2 max]***
*Award **[1]** each for any two*

E2. (a) (i) cryolite / Na_3AlF_6;

acts as a solvent;
lowers the melting point of aluminium <u>oxide</u>/<u>Al_2O_3</u> / allows lower temperature to be used;
saves fuel / electricity; ***[3 max]***
*Award **[1]** each for two of last three*

(ii) $2O^{2-} \rightarrow O_2 + 4e^- / 2O^{2-} - 4e^- \rightarrow O_2$;
Accept e instead of e^-

oxygen produced oxidizes/burns electrodes/forms carbon dioxide; ***[2]***

(b) (i) lower density; ***[1]***
Do not accept lighter.

(ii) more resistant to corrosion / forms oxide layer/film / iron rusts; ***[1]***

E3. oxide/SiO_2 heated with carbon;
$SiO_2 + C \rightarrow Si + CO_2$ / $SiO_2 + 2C \rightarrow Si + 2CO$;

impure silicon reacted with chlorine;
$Si + 2Cl_2 \rightarrow SiCl_4$;
purified by distillation;
heated with hydrogen/magnesium;
$SiCl_4 + 2H_2 \rightarrow Si + 4HCl$ / $SiCl_4 + 2Mg \rightarrow Si + 2MgCl_2$;
purified by zone refining;
silicon rod heated along its length;
impurities collect at one end; ***[6 max]***
*Award **[1]** for any correct equation, and **[1]** each up to **[4 max]** for any of the seven remaining points.*

E4. (a) initiation;
propagation;
termination; ***[2]***
*Award **[2]** for all three, **[1]** for any two*

(b) (organic) peroxide; ***[1]***

(c) $RO\bullet + H_2C{=}CH_2 \rightarrow RO{-}CH_2{-}CH_2\bullet$; ***[1]***
Do not penalise missing • symbol

Option F – Fuels and energy

F1. (a) For C(s) $\Delta H_c^{\ominus} = -394/395$ and $M_r = 12.01$;
calorific value $= 32.8 / 33\ (\text{kJ g}^{-1})$;
For CH_4 (g) $\Delta H_c^{\ominus} = -890$ and $M_r = 16.05$;
calorific value $= 55.5 / 56\ (\text{kJ g}^{-1})$; ***[4]***
If 12 and 16 used instead of Data Booklet values, penalise once only

(b) (i) $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$; ***[1]***
State symbols not needed

(ii) bond energies of bonds formed greater than those of bonds broken / weaker bonds broken and stronger bonds made / products have lower enthalpy than reactants; ***[1]***

F2. (a) $C + H_2O \rightarrow CO + H_2$; ***[1]***

(b) (i) *synthesis gas has*
no sulfur dioxide / contains no sulfur (compounds);
no acid rain;
no soot;
only CO_2 and H_2O are produced; ***[2 max]***
Award ***[1]*** *each for any two.*

(ii) (cost of) the energy used; ***[1]***

F3. (a) (in both fission and fusion reactions) there is a loss of mass / mass of products is less than mass of reactants;
mass converted to energy; ***[2]***

(b) (i) $^{213}_{84}\text{Po}$ ***[2]***
*Award **[1]** for Po and **[1]** for atomic and mass numbers.*

(ii) three half-lives;
0.015 g;
Unit needed for mark ***[2]***
*Award **[2]** for correct final answer without working.*

(c) $^{7}_{3}\text{Li} + ^{1}_{1}\text{p} \rightarrow 2^{4}_{2}\text{He}$; ***[1]***

F4. (a) $^{227}_{89}\text{Ac}$;
$^{52}_{26}\text{Fe}$; ***[2]***

(b) loss of alpha / beta particle;
$^{227}_{89}\text{Ac} \rightarrow ^{223}_{87}\text{Fr} + ^{4}_{2}\text{He} / ^{227}_{89}\text{Ac} \rightarrow ^{227}_{90}\text{Th} + ^{0}_{-1}\text{e}$;

loss of positron / electron capture;
$^{52}_{26}\text{Fe} \rightarrow ^{52}_{25}\text{Mn} + ^{0}_{1}\text{e} / ^{52}_{26}\text{Fe} + ^{0}_{-1}\text{e} \rightarrow ^{52}_{25}\text{Mn}$; ***[4]***
ECF from part (a)

(c) mass change $= 1.3950466 \times 10^{-30}$ /
$1.674954 \times 10^{-27} - (1.672648 \times 10^{-27} + 9.109534 \times 10^{-31})$;
$(E = mc^2 =) 1.255542 \times 10^{-13} / 1.25554194 \times 10^{-13}$ J; ***[2]***
Unit needed for second mark, no sig fig penalty

Option G – Modern analytical chemistry

G1. (bond) stretching / change in bond length;
bending / change in bond angle;
non-polar / no (change in) dipole moment; ***[3]***

G2. (a) number of peaks indicates the number of different environments for hydrogen atoms/ protons / *OWTTE*;
area under each peak indicates the (relative) numbers of hydrogen atoms in each environment / *OWTTE*;
δ 1.3 indicates CH_2 attached to alkyl group / CH_2 as part of hydrocarbon chain;
δ 9.7 indicates H attached to carbonyl group / aldehyde; ***[4]***
Do not accept formulas in the Data Booklet

(b) (i) triplet due to CH_2 group / due to 2 protons on neighbouring carbon;
quartet due to CH_3 group / due to 3 protons on neighbouring carbon;
ethyl group / CH_3 and CH_2 next to each other; ***[3]***

(ii) CH_3/methyl group;
there are no protons on the neighbouring carbon atom; ***[2]***

(iii) ethyl ethanoate spectrum 1 and methyl propanoate spectrum 2;

singlet at $\delta = 2.0 / 2.1$ due to CH_3 next to CO / COOR;
singlet at $\delta = 3.8$ due to CH_3 next to O; ***[3]***

(c) 3;
6:1:1; ***[2]***

G3. (a) (i) 92 due to ^{35}Cl and 94 to ^{37}Cl / there are two isotopes of chlorine;
present in ratio 3:1 / abundances are 75 % and 25 %; ***[2]***

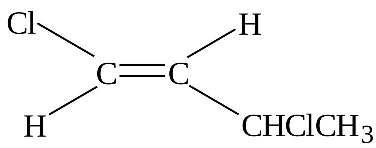
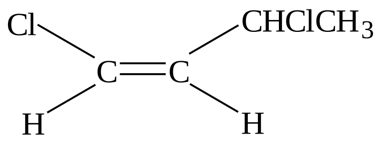
(ii) (m/z = 77) $C_3H_6Cl^+$ / $(CH_3)_2CCl^+$;
(m/z = 57) $C_4H_9^+$ / $(CH_3)_3C^+$; ***[2]***
Penalize missing charges once only

(b) 84
86
88 ***[2]***
Award ***[2]*** *for all three correct,* ***[1]*** *for any two correct.*

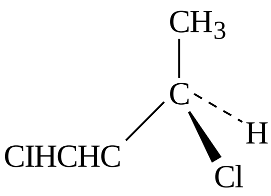
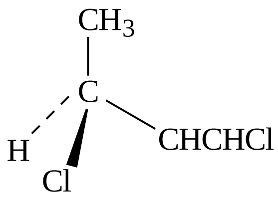
(c) ^{13}C ;
the number of carbon atoms in the molecule; ***[2]***

Option H – Further organic chemistry

H1. (a)

one correct structural formula;
two distinct isomeric structures shown;

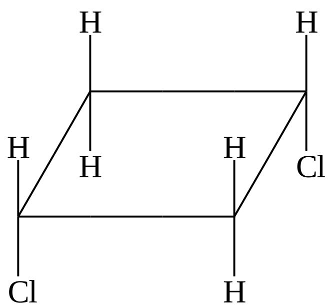
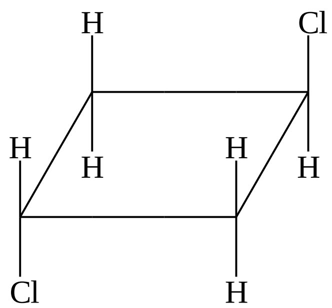
 

one correct structural formula shown as 3-D;
two distinct isomeric structures shown; ***[4]***

(b) it contains equal amounts/moles of the two optical isomers/enantiomers/ d (dextro/dextrorotatory) and l(levo/levorotatory); ***[1]***

(c) polarimeter / plane-polarized light;
plane (of polarization) rotated in opposite directions;
no rotation for racemic mixture; ***[3]***

(d)

one correct structural formula;
two distinct isomeric structures shown; ***[2]***

H2. (a) (mechanism showing)
arrow from C=C double bond towards I;
arrow from I-Cl bond to Cl;
carbocation showing I on first carbon and + charge on second carbon;
arrow from Cl^- to carbon with + charge and structure of product; ***[4]***

(b) 1-chloro-2-iodobutane / 2-iodo-1-chlorobutane;
formed via a primary carbocation;
which is less stable than the secondary carbocation;
fewer electron-releasing alkyl groups / positive charge spread out less; ***[4]***

H3. (a) S_N2 / bimolecular; ***[1]***

(b) (i) reaction slower;
neutral / uncharged / less polar / electrons donated less easily in H_2O ; ***[2]***

(ii) reaction faster;
less bulky group / reduced steric hindrance; ***[2]***

(c) (attacking) nucleophiles repelled by delocalized/pi electrons;
C–Cl bond stronger / less easily broken;
because lone pairs/p electrons on Cl interact with delocalized/pi electrons; ***[2 max]***
*Award **[1]** each for any two*