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

N05/4/CHEMI/SP3/ENG/TZ0/XX/M+

MARKSCHEME

November 2005

CHEMISTRY

Standard Level

Paper 3

16 pages

Subject Details: Chemistry SL 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 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.

Option A – Higher physical organic chemistry

A1. (a) first order (with respect to O_2); ***[1]***

(b) second order (with respect to NO); ***[1]***

(c) rate $= k[NO]^2[O_2]$; ***[1]***
Allow ECF from parts (a) and (b).

(d) $k = \dfrac{3.75\times10^{-3}}{(3.50\times10^{-2})^2\ (1.75\times10^{-2})} = 1.75\times10^{2}$;
$dm^6mol^{-2}s^{-1}$; ***[2]***
*Award **[1]** mark for the answer and **[1]** mark for units.*
Allow ECF from part (c).

(e) $NO + NO \rightleftharpoons N_2O_2$;
$N_2O_2 + O_2 \rightarrow 2NO_2$;
second step is rate determining step;
Allow ECF from part (c).

OR

$NO + O_2 \rightleftharpoons NO_3$;
$NO_3 + NO \rightarrow 2NO_2$;
second step is rate determining step; ***[3]***
Allow ECF from part (c).

A2. (a) $(CH_3)_3CI \rightarrow (CH_3)_3C^+ + I^-$;
$(CH_3)_3C^+ + OH^- \rightarrow (CH_3)_3COH$; ***[2]***
Do not allow S_N2 reaction.

(b) Step 1 **and** because it is a slow step/because it has high activation energy/
because it involves bond breaking; ***[1]***

(c) (i) less than because C—Cl bond is stronger; ***[1]***

(ii) equal because first order kinetics/rate determining step does not involve KOH/
OWTTE; ***[1]***

A3. (a) (i) $K_w = [H^+][OH^-]$; ***[1]***

(ii) $[H^+] = 1.5 \times 10^{-7}$ (mol dm^{-3}); ***[1]***
Accept answer in range 1.5 to 1.55.

(b) (i) $CH_3CH(OH)COOH + H_2O \rightleftharpoons CH_3CH(OH)COO^- + H_3O^+$; ***[1]***
Ignore state symbols even if incorrect.
The double arrow is necessary for the mark.

(ii) $K_a = \dfrac{[CH_3CH(OH)COO^-][H^+]}{[CH_3CH(OH)COOH]}$; ***[1]***
Allow $[H_3O^+]$ *for* $[H^+]$ *in the expression.*

(iii) $5.3 \times 10^{-3} = [H^+]$;
pH = 2.3; ***[2]***
Allow ECF pH based on wrong $[H^+]$ *in the value, award* ***[1]****.*
Award ***[2]*** *for correct pH.*

(iv) pH = 3.85; ***[1]***
Accept answer in range 3.8 to 3.9.

Option B – Medicines and drugs

B1. (a) $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$ / $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$; ***[2]***
*Award **[1]** for correct reactants and products and **[1]** for balancing.*

(b) $Al(OH)_3$/aluminium hydroxide; ***[1]***

(c) corrosive to body/tissue;
strong base/alkali; ***[2]***

B2. (a) oxidizing agent/accepts electrons;
orange to green; ***[2]***

(b) (gas-liquid) chromatography;
infra-red spectroscopy; ***[2]***

(c) stomach bleeding/"corrodes lining" of stomach; ***[1]***

(d) amide/ketone/carbonyl;
(tertiary) amine; ***[2]***

B3. (a) (i) antipyretic/reducing fever; ***[1]***

(ii) anti-inflammatory/anti-clotting / prevention or treatment of heart attacks/strokes; ***[1]***

(b) (i) ether;
alkene/carbon to carbon double bond;
(tertiary) amine; ***[2 max]***
*Award **[1]** each for any two.*

(ii) *main effect*
pain relief;

side effect
constipation; ***[2]***

(c) (i) LD_{50} is the dose that is lethal for 50 % of the population; ***[1]***

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

Option C – Human biochemistry

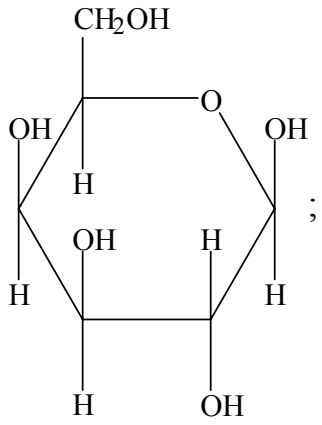
C1. (a) (i) *α glucose*
A;

β glucose
C; ***[2]***

(ii) no **and** because they are not mirror images/because they are both D isomers/ because OH group is below the plane at C1 or OH group is above at C1; ***[1]***

(iii) 1 and 6; ***[1]***

(b)



;

β isomer; ***[2]***

(c) energy storage / reserve; ***[1]***

C2. (a) (i) 2 double bonds; ***[1]***

(ii) 280.5 g linoleic acid adds to 507.6 g I_2;

100 g adds to $\frac{507.6 \times 100}{280.5} = 181$; ***[2]***

Allow ECF from (i).
Do not penalize for use of whole number atomic masses.

(b) (i) both are tri-glycerides/tri-esters/made up from glycerol joined to three fatty acids; ***[1]***

(ii)

Fats		***Oil***
saturated/no C=C bonds	***or***	unsaturated/1 or more C=C bonds;
(saturated) chains pack closely	***or***	(unsaturated) chains pack less closely;
van der Waal's forces are stronger	***or***	van der Waal's forces are weaker; ***[3]***

Accept intermolecular forces for van der Waal's forces.

(c) (i) boil/heat/high temperature; ***[1]***
Allow a specified range of temperature 40 to 150 °C .

(ii) $CH_2OH\text{-}CHOH\text{-}CH_2OH$; ***[1]***
Accept more detailed structures.

C3. (a) *vitamin A*
night blindness / xerophthalmia;

vitamin C
scurvy / scorbutus;

vitamin D
rickets; ***[2]***
*Award **[2]** for 3 correct, **[1]** for 2 correct.*

(b) *vitamin A*
is stored (in the body) because it is fat-soluble;

vitamin C
is excreted because it is water-soluble; ***[2]***

Option D – Environmental chemistry

D1. (a) (i) CO;
NO/ NO_X;
hydrocarbons;
particulates;
*Award **[2]** for three correct, **[1]** for two correct and **[0]** for one correct.*

CO, hydrocarbons and particulates formed from the incomplete combustion of fuel;
For NO, high temperature (in an internal combustion engine); ***[4 max]***

(ii) $2CO + 2NO \rightarrow 2CO_2 + N_2$; ***[2]***
*Award **[1]** for all correct formulas and **[1]** for balancing.*

(iii) *natural*
oxidation of H_2S/ (active) volcanoes;

man made
combustion of coal/smelting of sulphide ores/manufacture of sulphuric acid; ***[2]***

(b) low reactivity;
low toxicity;
low flammability;
no C–Cl bonds;
less absorption of infrared radiation; ***[3 max]***
*Award **[1]** each for any three.*

D2. (a) *three methods*
distillation;
reverse osmosis;
ion-exchange;

features of distillation
seawater is heated to its boiling point under reduced pressure;
vaporisation of water (leaving behind dissolved impurities);
condensation of water (free of impurities);

OR

features of reverse osmosis
partially permeable/semi-permeable membrane;
use of high pressure/compressed/pressure greater than osmotic pressure/
pressure greater than 70 atm;
pure water passes through (semi-permeable membrane);
salt/dissolved ions do not pass through;
*Award **[1]** each for any three.*

OR

features of ion exchange
positive (ion exchange) resin replaces cations in sea water by H^+;
negative (ion exchange) resin replaces anions with OH^-;
H^+ and OH^- combine to form H_2O; ***[6 max]***

(b) *similarity*
oxidizing agents/kill microorganisms/kills bacteria;

difference

Chlorine		*Ozone*
kills only bacteria	***or***	kills (bacteria and) viruses;
cheap(er)	***or***	(more) expensive;
longer retention time	***or***	shorter retention time;
toxic chloro compounds;	***or***	no toxic compounds;
not necessary to produce on site;	***or***	prepared on site;
can leave after taste;		***[3 max]***

*Award **[1]** each for any two.*

Option E Chemical industries.

E1. (a) aluminium has high negative $E^{\ominus}$ value/Al is more reactive than carbon/
Al has a higher affinity for oxygen compared to carbon; ***[1]***

(b) strong (electrostatic) attraction between ions of high charge density/*OWTTE*;
OR
ionic bonds are strong and require much energy to break/*OWTTE*; ***[1]***

(c) cryolite lowers melting point of alumina/acts as a solvent; ***[1]***
Do not accept "cryolite lowers melting point of aluminium".

(d) *positive electrode (anode)*
$2O^{2-} \rightarrow O_2 + 4e^-$;

negative electrode (cathode)
$Al^{3+} + 3e^- \rightarrow Al$; ***[2]***
*Award **[1]** for correct equations at wrong electrodes.*

(e) graphite/electrode reacts/burns in oxygen; ***[1]***

E2. (a) acts as reducing agent/reduces iron oxide/converted to carbon monoxide; ***[1]***

(b) SiO_2 / sand;
calcium oxide is basic and reacts with acidic SiO_2; ***[2]***

(c) (i) oxygen;
lime(stone)/calcium oxide/calcium carbonate; ***[2]***

(ii) impurities are oxidized;
oxidized impurities react with calcium oxide / lime(stone) to form slag; ***[2]***

(d) protective layer of (aluminium) oxide; ***[1]***

E3. (a) *aromatization*
benzene **and** C_6H_6 ;

cyclization
cyclohexane **and** C_6H_{12} ;

isomerization
3-methylpentane **and** $CH_3CH_2CH(CH_3)CH_2CH_3$; ***[3]***

Accept other isomers and the formula C_6H_{14} .
*Name and formula for **[1]** each*.

(b) on combustion / burning forms SO_2 ;
SO_2 is poisonous / forms acid rain;
poisons catalyst / *OWTTE*; ***[2 max]***
*Award **[1]** each for any two*.

(c) H_2 / hydrogen; ***[1]***

Option F – Fuels and Energy

F1. (a) $\left(\frac{890}{16} =\right)$ 55.6 (kJ);
$\left(\frac{5512}{114} =\right)$ 48.4 (kJ); ***[2]***

(b) (i) removal of sulfur compounds from coal is difficult / *OWTTE*;

(ii) high temperature in internal combustion engines;

(iii) incomplete combustion / insufficient oxygen; ***[3]***

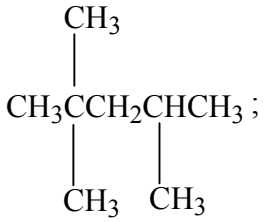
(c) $CH_4 + 1\frac{1}{2}O_2 \rightarrow CO + 2H_2O$; ***[1]***

(d) 200 dm^3 (O_2);
1000 dm^3 (of air is required); ***[2]***

(e) liquid (at room temperature);
readily transforms into vapour / volatile / low bowling point; ***[2]***

(f) *octane number* = 0
$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$;

octane number = 100



; ***[2]***

(g) kerosine; ***[1]***

F2. (a) *anode (oxidation)*
$Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$;

cathode (reduction)
$PbO_2 + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$; ***[2]***

(b) *oxidizing agent*
PbO_2;

reducing agent
Pb; ***[2]***

(c) concentration decreases/density decreases/acidity decrease/pH increase; ***[1]***

(d) *advantage*
rechargeable / delivers large amounts of energy;

disadvantage
bulky / acid spillage / heavy / toxic; ***[2]***