MARKSCHEME

November 2005

CHEMISTRY

Higher Level

Paper 3

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 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 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; ***[1]***

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

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

(c) stomach bleeding; ***[1]***

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]***

B4. (a) (i) cisplatin and geometric / cis-trans isomerism;
Taxol® and optical isomerism; ***[2]***
Accept other correct examples.

(ii) atoms/groups arranged differently in space/*OWTTE*;
chiral/asymmetric carbon atom/carbon joined to 4 different atoms/groups; ***[2]***

(b) chiral auxiliary attaches to starting molecule;
chosen reagents convert starting molecule into only one enantiomer;
chiral auxiliary removed to leave desired enantiomer;
chiral auxiliary is itself optically active/possess a chiral atom; ***[2 max]***
*Award **[1]** each for any two*.

B5. (a) *local*
acts on small part of the body, (patient) conscious;

general
acts on brain, (patient) unconscious; ***[2]***

(b) procaine and lidocaine;
addictive / acts as stimulant; ***[2]***

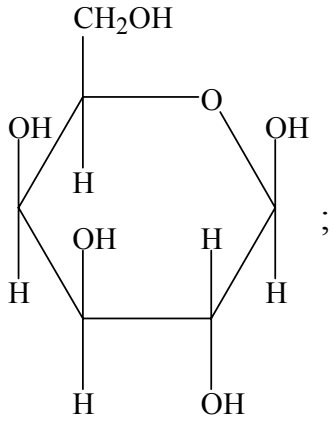
Option C – Human biochemistry

C1. (a) (i) *α glucose* and *β glucose*
A; C; ***[1]***

(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]***

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 esters/tri-glycerides/tri-esters; ***[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.

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

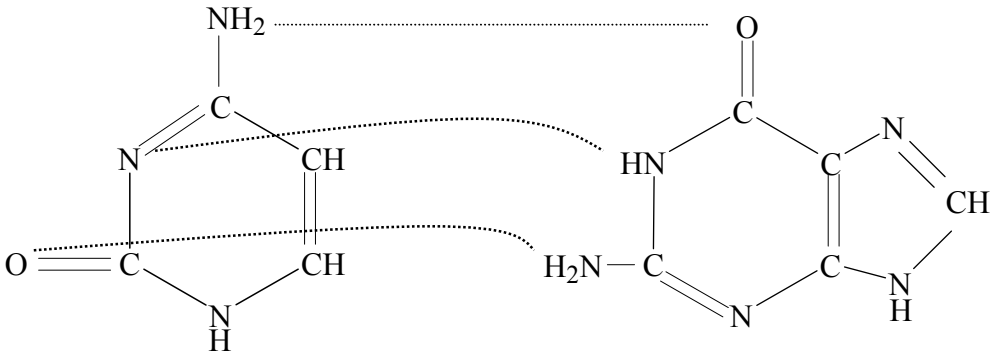
vitamin C
scurvy / scorbutus;

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]***

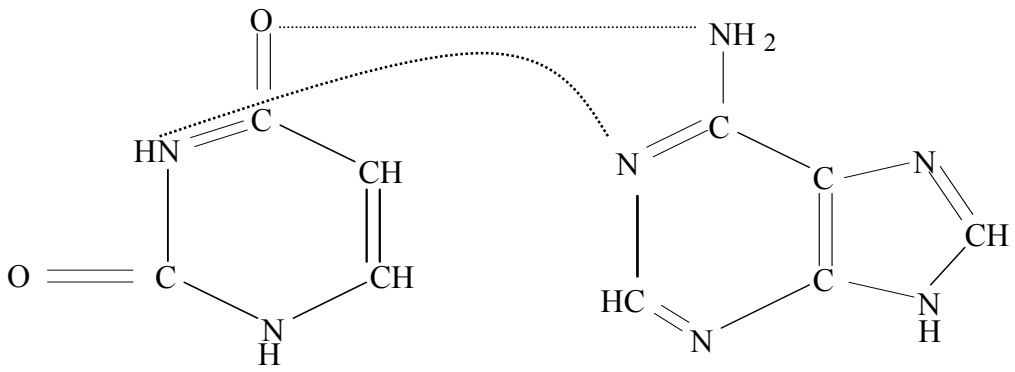
C4. (a) 3 H bonds shown correctly between C and G; ***[2]***
2 H bonds shown correctly between C and G; ***[1]*** ***[2 max]***



cytosine guanine

(b) uracil (pairs with adenine);

2 H bonds shown correctly between U and A;
OR
2 H bonds shown correctly between T and A; ***[2]***



uracil adenine

(c) Sequence of three bases representing one amino acid; ***[1]***

(d) Potassium / K^+ has lower charge density / K^+ has same charge as Na^+ but larger size; ***[1]***

(e) Fe^{2+} / Fe^{3+};
Cu^+ / Cu^{2+}; ***[2]***

(f) coordinate / dative; ***[1]***
Accept covalent.

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

(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;
*Award **[2]** for 3 correct, **[1]** for 2 correct.*

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; ***[5 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 taste;		***[2 max]***

*Award **[1]** for any one.*

D3. (a) (i) SO_2 / sulfur dioxide;
particulates / soot / flyash / carbon monoxide; ***[2]***

(ii) $2SO_2 + O_2 \rightarrow 2SO_3$;
particulates as catalyst / heterolytic catalysis;

$SO_2 + O \rightarrow SO_3$ / $SO_2 + NO_2 \rightarrow SO_3 + NO$;
UV light / free radical catalysis; ***[4]***
Award marks (ECF) for correct formation of secondary pollutants from any primary pollutant(s).

(iii) SO_2 alkaline scrubber / fluidized bed combustion
OR
particulates electrostatic precipitators / cyclone separator;
OR
use of a catholytic converter (for reducing CO); ***[1]***

(b) NO / NO_x / NO_2 act as catalysts;
$NO + O_3 \rightarrow NO_2 + O_2$;
$NO_2 + O \rightarrow NO + O_2$; ***[3]***

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.*

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]***

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

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

isomerization
3-methylpentane **and** $CH_3CH_2\underset{\displaystyle CH_3}{\underset{|}{C}}HCH_2CH_3$; ***[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*; ***[1]***

E4. (a) use of high temperature ($\approx 800\,°C$) in steam and lower temperature in catalytic ($\approx 450\,°C$);
homolytic fission in steam and heterolytic fission in catalytic;
steam – free radical mechanism and catalytic – ionic mechanism; ***[3]***

(b) aluminium oxide / silicon dioxide;
carbocation / carbonium ion; ***[2]***

E5. (a) requires less energy;
useful by products; ***[2]***

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

negative electrode (cathode)
$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$;
OR
$2H^+ + 2e^- \rightarrow H_2$; ***[2]***

Accept correct equations at wrong electrodes for ***[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]***

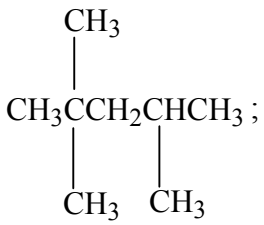
(d) 200 dm^3 O_2;

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

(e) *octane number* = 0

$CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$;

octane number = 100



; ***[2]***

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) concentration decreases/density decreases/less acidic/pH increase; ***[1]***

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

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

F3. (a) C (diamond) has no mobile electrons whereas Ge has some mobile electrons;
in diamond all electrons are localized in covalent bonds, in Ge some electrons are delocalized as it is a metalloid; ***[2]***

(b) indium has 3 outer e^- / has 1 e^- less than Si / produces a positive charge / electron hole;
arsenic has 5 outer e^- / has 1 e^- more than Si / produces a negative charge;
indium – p-type semi-conductor;
arsenic – n-type semi-conductor; ***[4]***

F4. *advantages*
large supply of raw materials containing H_2 / *OWTTE*;
non-polluting / only product of combustion is H_2O ;
produces large amounts of heat per gram of fuel / *OWTTE*;
*Award **[1]** each for any two.*

disadvantages
cannot be liquefied easily;
hydrogen – air mixture is explosive;
storage problems of gas;
energy required to produce it; ***[4]***
*Award **[1]** each for any two.*

Option G – Modern analytical chemistry

G1. (a) (i) C_3H_8O , peak at 60 due to molecular ion/ molar mass 60; ***[1]***

(ii) *isomer A*
29 $C_2H_5^+$;
31 CH_2OH^+ / CH_3O^+ ;

isomer B
30 $CHOH^+$ / CH_2O^+ ;
45 CH_3-$CHOH^+$ / $C_2H_5O^+$; ***[4]***
If + charge missing, penalize once only.

(b) (i) $Si(CH_3)_4$ / SiC_4H_{12} ;
used as reference standard; ***[2]***

(ii) *number of peaks*
different chemical environments occupied by the protons / H atoms;

area under each peak
number/ratio of H atoms / protons in each particular chemical environment; ***[2]***

(iii) *isomer A*
$CH_3CH_2CH_2OH$;
ratio:
3 : 2 : 2 : 1;

isomer B
$(CH_3)_2CHOH$;
ratio:
6 : 1 : 1; ***[4]***

(iv) $CH_3OCH_2CH_3$;
3 : 2 : 3; ***[2]***

G2. (a) place sample on paper / thin layer;
elute suitable solvent;
develop with ninhydrin;
measure Rf value;
compare with known value; ***[4 max]***
*Award **[1]** each for any four*.

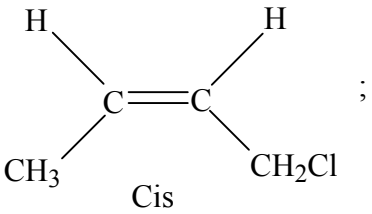
(b) gas-liquid chromatography / GLC;
stationary phase is long chain alkanes;
adsorbed on the surface of the oxide;
mobile phase inert gas / N_2 / He;
sample is vaporised;
components have separate retention time;
flame detector/ionizer used (to detect eluted alcohol);
reference sample used to calibrate peak area/concentration (of alcohol);
*Award **[1]** each for any six*.

OR

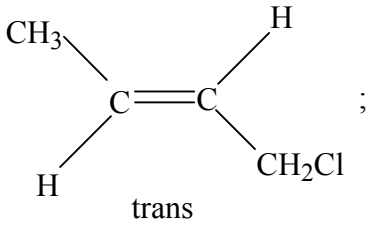
high performance liquid chromatography (HPLC);
stationary phase is long chain alkanes;
adsorbed on the surface of the oxide;
mobile phase is liquid under pressure;
sample is in liquid phase;
components have separate retention time;
eluted components/alcohol detected by UV spectres copy/flame ionization;
reference sample used to calibrate peak area/concentration (of alcohol); ***[6]***
*Award **[1]** each for any six*.

Option H – Further organic chemistry

H1. (a) (i) no rotation possible due to double bond/π bond; ***[1]***
Accept restricted or hindered rotation.

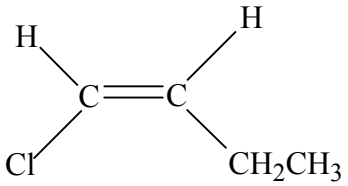
(ii) 

Cis ;

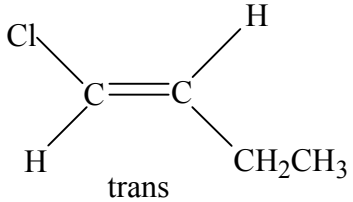


trans ;

OR

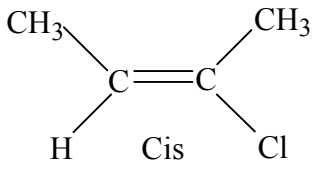


Cis ;

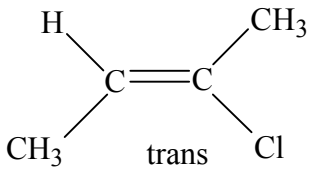


trans ; ***[2]***

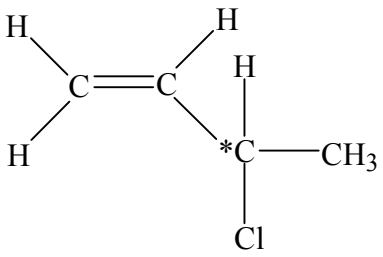
OR



Cis

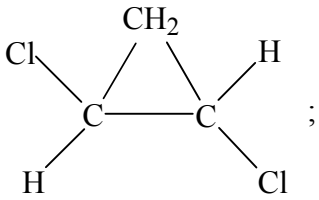


trans ***[2]***

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

*Award **[1]** for the structure and **[1]** for showing * on the correct carbon atom.*

(b) restricted rotation because C—C bond is now part of a cyclic system;

 ;

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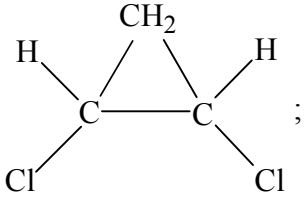
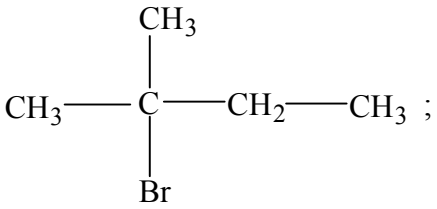
 ; ***[3]***

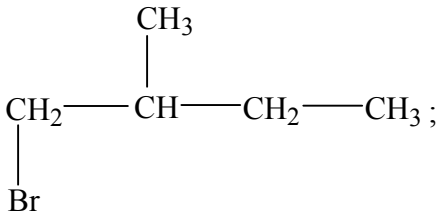
Cis

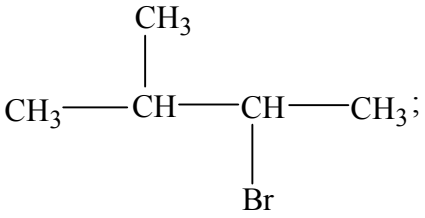
H2. (a)



tertiary carbocation;
more stable;
due to 3 electron releasing alkyl groups / positive inductive effect; ***[4]***

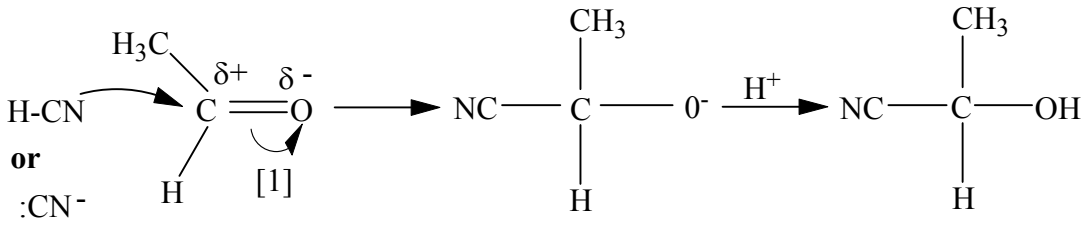
(b)





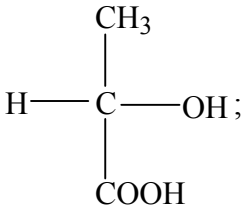
[2]

H3. (a) Nucleophillic addition reaction; ***[5]***



[1] ***[1]*** Intermediate ***[1]*** Product

(b)



[1]

(c) Racemic / 50:50 mixture of two enantiomers; ***[1]***

H4. (a) alkyl group is electron releasing / positive inductive effect;
electron density on N atom greater; ***[2]***

(b) NO_2 group is electron withdrawing / negative inductive effect;
negative charge delocalised on the ring; ***[2]***