MARKSCHEME

May 2003

CHEMISTRY

Higher Level

Paper 3

15 pages

General Marking Instructions

After marking a sufficient number of scripts to become familiar with the markscheme and candidates' responses to all or the majority of questions, Assistant Examiners (AEs) will be contacted by their Team Leader (TL) by e-mail or telephone. The purpose of this contact is to discuss the standard of marking, the interpretation of the markscheme and any difficulties with particular questions. It may be necessary to review your initial marking after contacting your TL. **DO NOT BEGIN THE FINAL MARKING OF YOUR SCRIPTS IN RED INK UNTIL YOU RECEIVE NOTIFICATION THAT THE MARKSCHEME IS FINALIZED.** *You will be informed by e-mail, fax or post of modifications to the markscheme and should receive these about one week after the date of the examination. If you have not received them within 10 days you should contact your Team Leader by telephone. Make an allowance for any difference in time zone before calling.* **AEs WHO DO NOT COMPLY WITH THESE INSTRUCTIONS MAY NOT BE INVITED TO MARK IN FUTURE SESSIONS.**

You should contact the TL whose name appears on your "Allocation of Schools listing" sheet.

Note:
Please use a personal courier service when sending sample materials to TLs unless postal services can be guaranteed. Record the costs on your examiner claim form.

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1. Follow the markscheme provided, do **not** use decimals or fractions and mark in **RED**.

2. Where a mark is awarded, a tick (✓) should be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark.

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation in the **left hand margin** to explain your decision. This is useful for moderation and re-marking.

4. Unexplained symbols or personal codes/notations on their own are unacceptable.

5. Record subtotals (where applicable) in the right-hand margin against the part of the answer to which they refer next to the mark allocation. Do **not** circle subtotals. **Circle the total mark for the question in the right-hand margin opposite the last line of the answer.**

6. Where an answer to a part question is worth no marks, put a zero in the right-hand margin.

7. For each Option: Add the totals for each question in the Option and write it in the Examiner column on the front cover.
Total: Add the marks awarded and enter this in the box marked TOTAL in the Examiner column.

8. After entering the marks on the front cover check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the front cover. **We have script checking and a note of all clerical errors may be given in feedback to examiners.**

9. Every page and every question must have an indication that you have marked it. Do this by **writing your initials** on each page where you have made no other mark.

10. If a candidate has attempted more than the required number of Options within the paper, mark only the required number in the order in which they are presented, **unless the candidate has indicated on the front cover the Options to be marked**.

11. A candidate can be penalized if s/he clearly contradicts him/herself within an answer.

Subject Details: Chemistry HL Paper 3 Markscheme

General

- Each marking point is usually shown on a separate line or lines.
- 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) rectally / by suppository, by inhalation, by injection (parenterally), by applying to skin / topically; ***[2]***
***[2]** for three, **[1]** for two.*

(b) (i) magnesium / Mg;
aluminium / Al;
calcium / Ca; ***[1]***
*Any two, **[1]** each.*

(ii) $NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$; ***[1]***

(iii) acid from the stomach rises into the esophagus; ***[1]***

(iv) as an anti-foaming agent / to prevent problem in (iii) / to prevent flatulence; ***[1]***

B2. (a) (i) a substance that reduces pain;
mild analgesics intercept pain at the source / interfere with production of substances that cause pain;
strong analgesics bond to receptor sites in the brain / prevent the transmission of pain impulses; ***[3]***

(ii) carboxylic acid / alkanoic acid;
ester; ***[2]***
Accept only these names.

(iii) *Any one of the following beneficial effects **[1]**.*
used to treat mini-strokes;
prevents heart attacks / reduces risk of heart attack / thins the blood / anticoagulant;
relieves symptoms of rheumatological diseases / anti-inflammatory;
reduces fever;

*Any one of the following side effects **[1]**.*
stomach bleeding;
allergic reaction;
Reye's syndrome;
hearing loss;
tinnitus (ringing in the ears);
gastrointestinal irritation (*e.g.* heartburn, nausea); ***[2]***

(b) (i) 14 / 14.03; ***[1]***

(ii) increasing amounts needed to produce same effect;
increasing amounts cause damage/death; ***[2]***

B3. (a) optical;
chiral / asymmetric carbon atom / carbon joined to 4 different atoms;
circle on diagram (around CH joined to N); ***[3]***

(b) alleviates morning sickness;
causes (limb) deformation in fetus; ***[2]***

B4. *for*:
effective for certain named diseases;
no more (or less) damaging than other drugs *e.g.* tobacco, alcohol;
personal freedom argument / more taxes / frees police to deal with more serious crimes;
*Arguments for **[2 max]***.

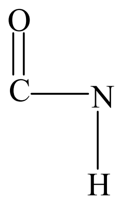
against:
some harmful effects / specified example, *e.g.* increased risk of lung cancer;
many users move on to more damaging / "harder" drugs; ***[4]***
*Arguments against **[2 max]***.

Option C – Human Biochemistry

C1. (a) $RCH(NH_2)COOH$; *[1]*

(b) $H_2NCH(CH_3)CONHCH_2COOH$ / $H_2NCH_2CONHCH(CH_3)COOH$;
water / H_2O ; *[2]*

(c) structure;
catalysis or enzymes;
energy source;
oxygen transport; *[2]*
*Any two, **[1]** each.*

(d) (i) acid / hydrochloric acid / HCl *(accept H_2SO_4)*;
Accept base / Na OH.
concentrated / heat or high temperature / time (*any two, **[1]** each*);
C—N /  / peptide / amide; *[4]*

(ii) mixture / amino acids spotted on paper/gel;
apply voltage;
develop / spray with ninhydrin / organic dye;
measure distances moved / compare with known samples / measure isoelectric point and compare with tables; *[4]*
Marks may be awarded for a suitable diagram.

C2. (a) (i) $CH_2OHCHOHCH_2OH$; *[1]*

(ii) 57; *[1]*

(b) $\frac{7.61}{253.8} = 0.03$ (mol) ;

3 (double bonds) *(ECF) (If 6, award **[1]**)*; *[2]*

C3. (a) enzyme lowers activation energy;
*Award **[1]** for how the activation energy is lowered e.g.*
enzyme binds to substrate / $E + S \rightleftharpoons ES$ then enzyme-susbtrate complex breaks up to give product and enzyme / $ES \rightarrow P + E$; ***[2]***

(b) (i) graph linear at low concentrations so rate increases as [S] increases / *OWTTE*;
because of more frequent E-S interactions/collisions;
graph flattens out at higher concentrations so rate unaffected by [S] / *OWTTE*;
because active sites on enzyme become occupied; ***[4]***

(ii) $V_{\mathrm{max}}: 630 \times 10^{-6}$ / 6.30×10^{-4} *(ignore units)*;
$K_{\mathrm{m}}: 12 - 13 \times 10^{-3}$ *(ignore units)*; ***[2]***
(*penalize once only if* $\times 10^{-x}$ *is missing*)

Option D – Environmental Chemistry

D1. (a) (i) (osmosis) – movement of solvent or water from dilute to concentrated solution / *OWTTE*;
(partially permeable membrane) – allows solvent or water but not solute particles to pass through / *OWTTE*; ***[2]***

(ii) sea water is compressed / subjected to high pressure;
pressure must be greater than osmotic pressure;
drinking / pure water passes through (partially permeable) membrane;
salt / dissolved solids left behind; ***[3]***
*Any three for **[1]** each.*

(iii) *Any reasonable suggestion*; ***[1]***

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

(ii) plant life / algae **increases** (then dies);
decay consumes dissolved oxygen; ***[2]***

D2. (a) amount of oxygen needed to decompose organic matter (in water sample);
in a specified time / 5 days / at a specified temperature / $20\,^{\circ}\mathrm{C}$; ***[2]***

(b) aeration / use of oxygen;
use of bacteria / micro-organisms;
organic matter;
broken down / oxidized;
sedimentation tank / settling process; ***[5]***
(*marks can be scored on a suitable diagram*)

D3. (a) O_2 has double bond;
O_3 has resonance structures / delocalization;
intermediate between double and single bonds / bond order of 1½ ;
bond in O_2 is stronger therefore I needs more energy (*do not give mark for I on its own with no justification*); ***[4]***

(b) the C–Cl bond breaks;
because it is the weakest bond;

$CCl_2F_2 \rightarrow CClF_2 + Cl$;
$Cl + O_3 \rightarrow ClO + O_2$;
$ClO + O \rightarrow O_2 + Cl$;
$ClO + O_3 \rightarrow Cl + 2O_2$; ***[5 max]***

*Following statements can score **[2 max] in lieu of equations**.*
forming radicals / by homolytic fission;
chlorine (radicals) react with ozone;
ClO and O radicals combine;

Option E – Chemical Industries

E1. (a) boil / vaporize crude oil;
(vapours) rise up column;
vapours condense / liquids form at different **heights**;
(heights depend on) boiling points / size of molecules; ***[4]***

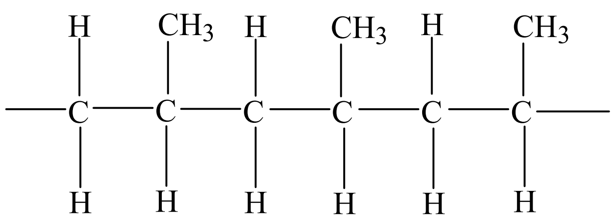
(b) (i) alumina / silica *etc.*;
$C_{14}H_{30} \rightarrow C_7H_{14} + C_7H_{16}$; ***[2]***

(ii) hydrogen;
saturated / branched / cyclic / aromatic; ***[2]***

(c) $C_6H_{14} \rightarrow C_6H_6 + 4H_2$;
feedstock for Haber process / fuel / margarine production; ***[2]***

E2. (a) (i) CH_2CHCH_3; ***[1]***

(ii)



;

stronger / harder / more rigid / higher melting point / more dense;
crystalline / chains closer together; ***[3]***

(b) carbon dioxide is a greenhouse gas / CO_2 causes global warming, climate change *etc.*;
produces toxic chlorine compounds / acid rain **due to HCl** / dioxin; ***[2]***

E3. (a) $2Cl^- \rightarrow Cl_2 + 2e^-$;
$2H^+ + 2e^- \rightarrow H_2$ / $2H_2O + 2e^- \rightarrow 2OH^- + H_2$;
Accept e instead of e^- in equations

any five from:
(sodium chloride) dissolved in water / brine;
positive electrode / anode made of titanium;
negative electrode / cathode made of steel;
diaphragm made of asbestos / fluorinated polymer;
chlorine formed at positive electrode / anode;
hydrogen formed at negative electrode / cathode;
sodium ions move through diaphragm towards negative electrode / cathode;
sodium hydroxide (solution) formed; ***[7 max]***

(b) mercury is toxic / health hazard / poisonous;
some reference to combining with organic molecules / entering food chain / damage to brain or nervous system *etc.*; ***[2]***

Option F – Fuels and Energy

F1. (a) heat;
pressure;
millions of years;
absence of oxygen / air; *[3]*
*Award **[1]** each, up to **[3 max]**.*

(b) CO / CO_2 / SO_2 / NO_X / particulates or C / hydrocarbons; *[2]*
*Three correct **[2]**, two correct **[1]**.*

F2. (a) (i) 1.49 *(V, units not needed)*;
$Zn + 2NH_4^+ \rightarrow Zn^{2+} + 2NH_3 + H_2$; *[2]*

(ii) to oxidize / remove the hydrogen / to prevent polarization / to prevent build-up of H_2 gas; *[1]*

(b) longer shelf life / more power / smaller voltage drop in use / no gas formed / last longer; *[2]*
*Any two **[1]** each.*

(c) (i) use more materials; *[1]*

(ii) join four together; *[1]*

F3. (a) $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$;
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$; *[2]*
Accept e instead of e^- in equations

(b) less waste heat produced / more chemical energy converted to useful energy / less polluting / renewable energy source / more efficient; *[1]*

F4. (a) (^{28}Mg) $n:p$ ratio $= 16:12 / 4:3 / 1.3:1$;
neutron has been converted to proton / ${}_{12}Mg \rightarrow {}_{13}Al$ (*may be shown in equation below*);
$(^{28}Mg) \rightarrow {}^{28}Al + {}^{0}_{-1}e$;
the n : p ratio is too high; *[4]*

(b) (high level) – contains fission products;
(low level) – clothing / fuel cans / other;

stored under water;
buried underground;
encased in steel / concrete;
vitrified / made into glass; *[6 max]*
*The last **four marks** can be scored without reference to either type of waste.*

Option G – Modern Analytical Chemistry

G1. (a) (H—O—H) bond angle changes / bending;
(H—O) bond length changes / stretching;
*Allow **[1]** for bonds vibrate if neither of the above points are scored.*
polarity (of bond or molecule) changes; ***[3]***

(b) B has O—H group / is an alcohol;
C has C═O / is a carbonyl compound / aldehyde or ketone ***[2]***

(c) 124 (*ECF*);
bromine has isotopes;
exists as ^{79}Br and ^{81}Br / peaks at M and M+2; ***[3]***

(d) CH_3CH_2CHO;
CH_3COCH_3; ***[2]***

(e) **C** is CH_3COCH_3;
no 14 or 29 means no CH_2 or C_2H_5 / 15 and 28 indicates CH_3 and CO; ***[2]***

(f) CH_3COCH_3 would have one line;
CH_3CH_2CHO would have three lines / *accept splitting pattern*; ***[2]***

G2. (a) (stationary phase) – water in the fibres of the paper (*do not accept just paper as the stationary phase*);
(mobile phase) – the solvent;
(partition) – distribution between the two phases;
(solvent front) – how far the solvent moves up the paper;
(R_f value) – the distance travelled by one component divided by the distance travelled by the solvent;
Above five points essential.

dyes spotted near bottom of paper;
bottom of paper placed in solvent;
solvent front below base line at beginning;
use of container with lid;
left until solvent near top of paper; ***[8]***
*Any three of these, **[1]** each.*

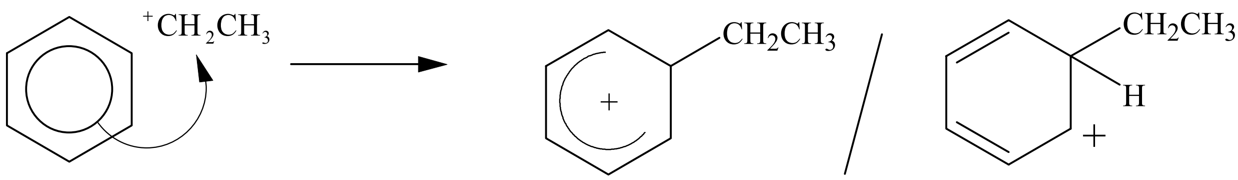
(b) (i) R_f value) $\dfrac{0.8\,(\pm 0.1)}{4.9\,(\pm 0.1)}$;
$= 0.16$ (*accept answer in range 0.14 – 0.20*); ***[2]***
*Allow **[1]** for* $\dfrac{1.8}{5.9} = 0.3$

(ii) mixture as more than one spot; ***[1]***

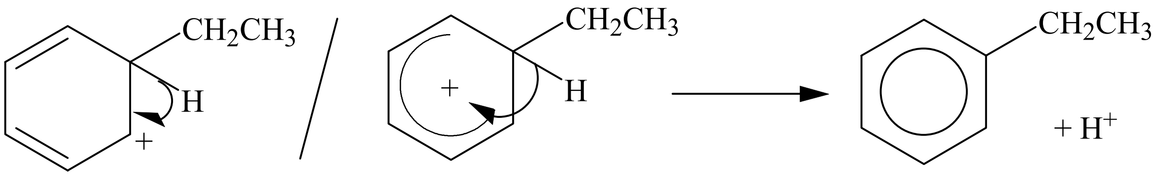
Option H – Further Organic Chemistry

H1. (a) (i) $C_6H_6 + CH_3CH_2Cl \rightarrow C_6H_5CH_2CH_3 + HCl$;

$CH_3CH_2Cl + AlCl_3 \rightarrow CH_3CH_2^+ + AlCl_4^-$;



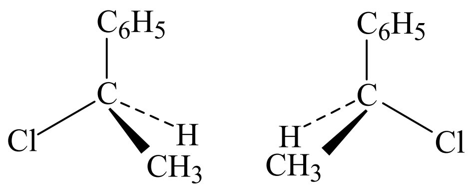
***[1]** for arrow* ***[1]** for intermediate*



[1]** for arrow* ***[5]

(ii) free radical substitution; ***[1]***

(b) (i) one correct structure;
second structure clearly a mirror image;
e.g.



[2]

(ii) light in which all waves / vibrations are in one plane;
plane-polarized light passed through each isomer (solution);
plane of polarization rotates;
in opposite directions for each isomer; ***[4]***

(iii) equal amounts of each isomer were formed / racemic mixture formed;
optical activities / rotations cancelled out; ***[2]***

(c) chlorobenzene;
nucleophile / OH^- repelled by delocalized electrons / carbon atom being attacked is less electron-deficient / carbon-chlorine bond is stronger; ***[2]***

H2. (a) higher K_a means stronger acid / lower K_a means weaker acid;
higher pK_a means weaker acid / lower pK_a means stronger acid; ***[2]***

(b) (phenol stronger / more acidic than ethanol) because the resulting anion is stabilized;
by delocalization/spreading of charge on aromatic ring / *OWTTE*; ***[2]***

(c) presence of electron-releasing groups decreases acid strength;
presence of electron-withdrawing groups increases acid strength;
propanoic weaker than ethanoic because of extra electron-releasing CH_2 group / the values are similar as the R groups have a similar effect;
dichloroethanoic stronger than chloroethanoic because of extra electron-withdrawing Cl;
fluoroethanoic stronger than chloroethanoic because of greater electronegativity/ electron-withdrawing power of F; ***[5]***
(*The first two points may be implicit in the explanations*)