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M04/420/H(3)M+

MARKSCHEME

May 2004

CHEMISTRY

Higher Level

Paper 3

17 pages

General Marking Instructions

This is the ONLY markscheme released for this session.

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.

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 cover sheet.
Total: Add the marks awarded and enter this in the box marked TOTAL in the Examiner column.

8. After entering the marks on the cover sheet, check your addition to ensure that you have not made an error. Check also that you have transferred the marks correctly to the cover sheet. **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 of Options in the order in which they are presented in the paper, **unless the candidate has indicated the Options s/he wants to be marked, on the cover sheet**.

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 incorrectly stated 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) *mild analgesics*
intercept pain stimulus at source */ OWTTE*;
strong analgesics
interact with receptor sites in the brain */ OWTTE*; ***[2]***

(b) amide;
(tertiary) amine; ***[2]***
Do not accept primary or secondary amine.

B2. (a) bacteria;

interfere with cell wall formation;
prevent formation of cross-links (within wall);
size/shape of cell cannot be maintained;
water enters the cell / osmosis occurs;
cell bursts / disintegrates; ***[4 max]***
*Award **[1]** each for any three of last five points*.

(b) (overprescription) makes penicillins less effective;
they destroy useful bacteria;
allow a resistant population to build up / *OWTTE*; ***[3]***

B3. bacteria are larger / viruses are smaller;
bacteria are cellular / viruses are non-cellular;
bacteria have nucleus / cytoplasm / cell membrane / organelles / opposite for viruses;

bacteria can feed / excrete / respire / grow outside cells / opposite for viruses;
Accept "bacteria are living whereas viruses are not living".

viruses insert DNA / RNA into cells / rely on a host cell to reproduce;
bacteria multiply by cell division / binary fision / mitosis / meiosis; ***[4 max]***
*Award **[1]** each for any four*.

B4. (a) *local*
block pain / effective close to where applied / injected;
general
cause loss of consciousness / administer by gas; ***[2]***

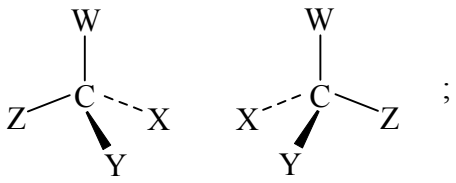
(b) *trichloromethane*
$CHCl_3$;

advantage	*disadvantage*
non-flammable;	toxic / leads to liver damage / lethal in slight excess / harmful to ozone layer;

cyclopropane
C_3H_6;

advantage	*disadvantage*
very potent / lower boiling point / more volatile;	flammable / risk of explosion / causes vomiting / headache; ***[6 max]***

B5. (a)



; ***[1]***

Must be clearly mirror images.

(b) an equimolar / 50:50 mixture of two enantiomers; ***[1]***

Option C – Human biochemistry

C1. (a) vitamin A / retinol is fat-soluble;

vitamin C / ascorbic acid is water-soluble;

vitamin D / calciferol is fat-soluble;

fat-soluble because mainly composed of hydrocarbon chain / non polar groups;
water-soluble because of presence of several/many hydroxyl / OH / polar groups; ***[5]***
*Last **[2]** can be scored even if classification wrong or not attempted.*

(b) (i) helps to form collagen / connective tissue / acts as antioxidant / maintains immune system / strengthens muscles; ***[1]***
Penalize for more than one answer <u>if incorrect</u>.

(ii) dissolves in water;
oxidized / destroyed by heating / boiling; ***[2]***

C2. (a) carbonyl / ketone;
Accept alkanone but not aldehyde.

alkene; ***[2]***

(b) progesterone;
ovaries; ***[2]***

(c) change release of hormones / FHS / LH (from hypothalamus / pituitary gland);
prevent ovulation / egg release;
prevent attachment of egg to uterus;
prevent sperm from reaching egg; ***[3 max]***
*Award **[1]** each for any three.*
Do not accept "mimic pregnancy".

C3. (a) protein;
catalyst; ***[2]***

(b) rate increases (at first / up to about 40 °C) because more substrate / reactant molecules have activation energy;
more successful collisions / interactions (between enzyme and substrate);
peak of graph represents optimum activity / fastest reaction;
rate decreases above about 40°C because tertiary / quaternary structure changes / enzyme denatured;
active site affected; ***[4 max]***
*Award **[1]** each for any four.*

C4. (a) Z;
lowest charge density so greatest / fastest mobility; ***[2]***

(b) X;
highest charge density so forms strongest bonds; ***[2]***

Option D – Environmental chemistry

D1. (a) fertilizer runoff / animal or human waste;
carcinogenic / lowers oxygen levels in the body / blue baby syndrome / infantile methaemoglobinaemia; ***[2]***

(b) tertiary;
ion exchange / microorganisms / algal ponds; ***[2]***

D2. to kill microorganisms / pathogens / germs / bacteria;

advantages of ozone
more effective than chlorine / against viruses;
leaves no taste;
does not produce harmful by-products / no poisonous chlorine compounds;
can be generated *in situ* / produced on site; ***[3 max]***
*Award **[1]** each for any two.*

D3. (a) incoming radiation / energy / heat / light (from sun) is short wavelength / ultra-violet (radiation);
long wavelength / infrared radiation, leaves Earth's surface;
(some of this radiation) is absorbed/trapped by gases in the atmosphere;
by (vibration in) bonds in molecules / re-radiates heat back to the Earth; ***[4]***

(b) *natural*
(evaporation from) oceans/seas/rivers/lakes;

man-made
burning (any specified) fossil fuels; ***[2]***
Do not accept objects such as "cars" or "car exhausts" or "aeroplanes" without a reference to combustion.

(c) (i) more abundant */ OWTTE*; ***[1]***

(ii) more effective (at absorbing energy) */ OWTTE*; ***[1]***

(d) melting of polar ice caps;
thermal expansion of oceans / rise in sea levels / coastal flooding;
stated effect on agriculture (*e.g.* crop yields changed);
changes in flora and fauna distribution;
stated effect on climate (*e.g.* drought / increased rainfall / desertification)
Do not accept "climate change" alone. ***[4 max]***
*Award **[1]** each for any four.*

D4. *origin*
burning gasoline / combustion products / volatile organic compounds;

weather
sunshine / hot / dry;
thermal/temperature inversion / layer of warm air traps cold air;

compounds
hydrocarbons / nitrogen oxides / ozone / aldehydes / peroxyacyl nitrates / PANs;
*Award **[1]** each for any two compound names or correct formulas.*
Do not award mark for SO_x *but do not penalize if given as an extra.*

health effects
effect on breathing / bronchitis / asthma / effect on eyes; ***[6]***

Option E – Chemical industries

E1. (a) (i) it can poison the catalysts used in oil refining;
it would form sulfur dioxide when burned;
leading to acid rain / affecting the catalyst in the catalytic converter / causing engine damage / causing health problems; ***[2 max]***
*Award **[1]** each for any two.*

(ii) $2H_2S + SO_2 \rightarrow 3S + 2H_2O$; ***[2]***
*Award **[1]** for all formulas correct, **[1]** for balancing.*

(b) (i) $(CH_3CH_2)_2CHCH_3$ C_6H_6

Isomerization; aromatization;
3-methylpentane; benzene;
[4]

(ii) hydrogen / H_2;
Haber process / ammonia production / hydrogenation / margarine manufacture / fuel / fuel cells; ***[2]***

E2. (a) Al_2O_3; ***[1]***

(b) it acts as a solvent;
it lowers the operating temperature / melting point;
it saves heat / energy; ***[2 max]***
*Award **[1]** each for any two.*

(c) $Al^{3+} + 3e^- \rightarrow Al$;
$2O^{2-} \rightarrow O_2 + 4e^-$; ***[2]***
Accept e instead of e^-.

E3. conductivity increases;

gallium has one less electron than silicon;
electron hole / positive centre / positive carrier introduced / p-type silicon;
so electron can move into these holes;
arsenic has one more electron than silicon;
spare / extra electron introduced / n-type silicon;
extra electrons free to move; ***[6 max]***
*Award **[1]** each for any five of last six.*

E4.

Species	Type of cracking	Type of bond fission
$CH_3CH_2CH_2^+$	catalytic;	heterolytic;
$CH_3CH_2CH_2\cdot$	thermal / steam;	homolytic;

[4]

Option F – Fuels and energy

F1. reduction of SO_2 emissions;
cheaper / easier to transport / versatile;
no solid waste (when burned); ***[2 max]***
*Award **[1]** each for any two.*

F2. (a) knocking / pre-ignition / *OWTTE*; ***[1]***

(b) 2,2,4-trimethylpentane; ***[2]***
*Award **[1]** for trimethylpentane, **[1]** for correct locants.*
*Award **[1]** for isooctane.*

(c) heptane is straight-chain / trimethylpentane is branched; ***[1]***

(d) branched alkanes / aromatic compounds / benzene compounds / lead compounds / tetraethyllead; ***[1]***
Do not accept "lead" alone.

(e) energy $= mc\Delta T / 250 \times 4.18 \times 52.7$;
energy 55.1×10^4 J;
Accept $55072\ J / 55.1\ kJ$.

M_r (heptane) $= 100$ (*or 100.23*);
energy given out per mole $\dfrac{55072}{\dfrac{2}{100}}$;

$$\Delta H = -\frac{55072}{\dfrac{2}{100}}$$

-2.75×10^6 J mol^{-1} / -2.75×10^3 kJ mol^{-1} ;
Accept answer in range 2.7×10^3 to 2.8×10^3 kJ mol^{-1}. ***[5]***
Must have correct unit and sign (*or indication or exothermic*).
Apply ECF throughout this part.

F3. *similarity*
mass converted to energy / *OWTTE*;

differences
(fission) one heavy nucleus / atom becomes two (or more) lighter ones;
(fusion) two light nuclei / atoms become one heavier one; ***[3]***

F4.

hydroelectric

advantages	disadvantges
do not produce chemical pollution;	energy lost because of conversion (to another form of energy);
can respond quickly to increased demand;	high capital cost;
	limited number of suitable sites;
	environmental impact

*Award **[1]** each for any **three** hydroelectric advantages or disadvantages.*
*Must include at **least one** advantage or disadvantage otherwise award **[2]** max.*

hydrogen

advantages	disadvantges
do not produce chemical pollution;	energy lost because of conversion (to another form of energy);
much heat released when hydrogen burned;	hard to liquefy / needs very low temperature / high pressure to liquefy;
portable	expensive to transport because of heavy containers;
	no infrastructure of pipelines available;
	risk of explosion;

*Award **[1]** each for any **three** hydrogen advantages or disadvantages.*
*Must include at **least one** advantage or disadvantage otherwise award **[2]** max.* ***[6 max]***

F5. (a) $^{225}\text{Ra} \rightarrow {}^{225}\text{Ac} + {}^{0}_{-1}\text{e}$; ***[1]***

Accept β particle instead of $^{0}_{-1}\text{e}$.
Penalize any wrong atomic number.

(b) $k = \frac{0.693}{t_{\frac{1}{2}}} / \frac{0.693}{14.8}$ or 0.04682 ;

$\ln\left(\frac{x_o}{x}\right) = kt$ or $t = \frac{\ln\left(\frac{x_o}{x}\right)}{k}$;

$t = 49.2$ days; ***[3]***

*Award **[1]** if candidates estimates between 3 and 4 half-lives.*

Option G – Modern analytical chemistry

G1. (a) $(C/D) - (CH_3)_3COH$;
$(C/D) - (CH_3)_2CHCH_2OH$; ***[2]***
C and D can be either way round.

(b) they have same functional groups / they all have an absorption in the range 2840 - 3095 / 1000 - 1300 / 3230 - 3550 cm^{-1}; ***[1]***

(c) (i) the number of different chemical environments of the hydrogen atoms / protons / *OWTTE*; ***[1]***

(ii) 5; ***[1]***
Accept 6 (if TMS has been inlcuded).

(iii) A
3 : 2 : 2 : 2 : 1;
Order not important

B
3 : 3 : 2 : 1 : 1; ***[2]***
Order not important

(d) C/D;
Depending on how $(CH_3)_3COH$ *is labelled in (a)*;

no adjacent carbon atoms with hydrogen atoms */ OWTTE*; ***[2]***

(e) (i) (this is due to) the molecular ion / $C_4H_{10}O^+$ / $C_4H_9OH^+$; ***[1]***

(ii) peak at 45 due to CH_3CHOH^+ / loss of C_2H_5;
peak at 31 due to CH_2OH^+ / loss of C_3H_7; ***[2]***

(f) (i) the triplet means next C has 2 H atoms / is CH_2 group;
the quartet means next C has 3 H atoms / is CH_3 group;

so presence of ethyl group / C_2H_5 / CH_3CH_2; ***[3]***
Award this mark if implied in (ii) even if not stated in (i).

(ii) *bond in E*
C—O;

structure of E
$CH_3CH_2OCH_2CH_3$; ***[2]***

G2. (a)

	Stationary phase	Mobile phase	
Adsorption	solid;	liquid;	
Partition	liquid;	liquid / gas;	***[3]***

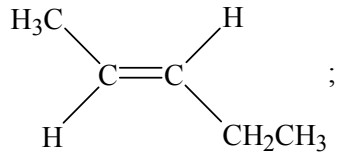
*Award **[3]** for four correct, **[2]** for three correct or **[1]** for two correct*.

(b) ratio of distances moved by solute and solvent / *OWTTE*; ***[1]***

(c) tube / column with alumina / silica (gel);
saturated with solvent;
mixture / solution added at top;
tap opened (at bottom);
more solvent added;
substances collected in separate containers; ***[4 max]***
*Award **[1]** each for any four*.

Option H – Further organic chemistry

H1. (a) (i)



;

[1]

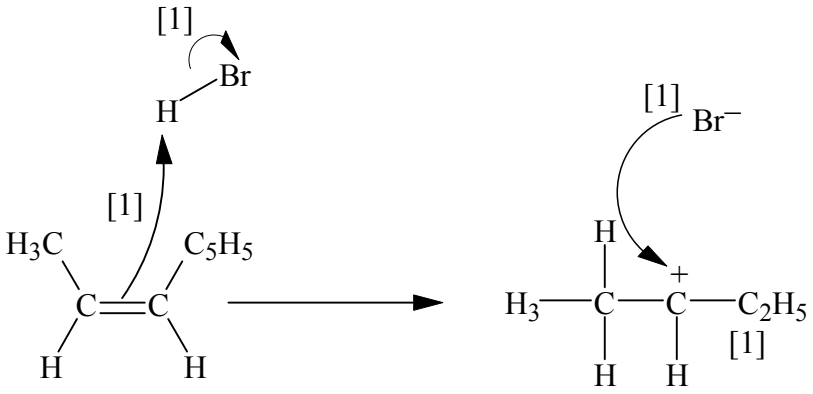
(ii) restricted rotation about C = C;
the bond cannot rotate as it would involve breaking π bonds;
groups at both ends different so rotation would produce a different molecule; ***[2 max]***
*Award **[1]** each for any two.*
Do not accept "molecule rotating" alone.

(iii) *cis*-pent-2-ene; ***[2]***
*Award **[1]** for pent-2-ene, **[1]** for cis.*

(b) (i) electrophilic addition; ***[1]***

(ii) $CH_3CHBrCH_2CH_2CH_3$;
(it contains) an asymmetric / chiral carbon atom / a carbon atom joined to four different groups; ***[2]***

(iii)



suitable diagram with
curly arrow from C = C to H of HBr;
curly arrow from H — Br bond to Br;
structure of carbocation $CH_3CH_2CH^+CH_2CH_3$;
attack by Br^- on carbocation; ***[4]***
If formation of Y *is shown, only third mark lost.*

(iv) (Markovnikov's rule states that) H adds to whichever C already has more H;

(in this case) both Cs have one H / the same number of H atoms; ***[2]***
Allow both formed via secondary carbocations.

(c) (i) OH^- / hydroxyl ion / H_2O ; ***[1]***

(ii) $(CH_3)_3CBr$
faster;
reaction proceeds via a more stable / tertiary carbocation;
more / three electron-releasing alkyl groups / greater positive inductive effect of alkyl groups;

C_6H_5Br
slower;
C—Br bond is stronger;
Due to a lone pair on Br delocalizing with π electrons in the benzene ring; ***[6]***

H2. $CH_3CH_2NH_2 + H_2O \rightarrow CH_3CH_2NH_3^+ + OH^-$;
Accept $\rightarrow$.
(ethylamine) more basic / higher basicity;
because of presence of electron-releasing (ethyl or alkyl) group;
N more electron-rich / attracts H^+ (or from H from H_2O) more easily; ***[4]***