INTERNATIONAL BACCALAUREATE BACCALAURÉAT INTERNATIONAL BACHILLERATO INTERNACIONAL
IBO

M03/420/H(2)M+

MARKSCHEME

May 2003

CHEMISTRY

Higher Level

Paper 2

18 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 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 FINALISED.** *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.

If you have any queries on **administration** please contact immediately:

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1. Follow the markscheme provided, do **not** use decimals or fractions and mark only 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. You are encouraged to write comments where it helps clarity, especially 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 for Section A). Do **not** circle sub-totals. **Circle the total mark for the question in the right-hand margin opposite the last line of the answer.**

6. For Section B, show a mark for each part question (a), (b), *etc.*

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

8. Section A: Add together the total for each question and write it in the Examiner column on the front cover.
   Section B: Insert the total for each question in the Examiner column on the front cover.
   Total: Add up the marks awarded and enter this in the box marked TOTAL in the Examiner column.

9. 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.**

10. 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.

11. If a candidate has attempted more than the prescribed number of questions within a paper or section of a paper, mark only the required number in the order in which they are presented in the script. Make a comment to this effect in the left hand margin.

12. A candidate can be penalised if he/she clearly contradicts him/herself within an answer. Make a comment to this effect in the left hand margin.

Subject Details: Chemistry HL Paper 2 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 penalised. 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, penalise 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 penalise 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, penalise 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 penalising 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

SECTION A

1. (a) (i) loss of 2 electrons / outer electrons;
3 shells to 2;
net attractive force increases; ***[2 max]***

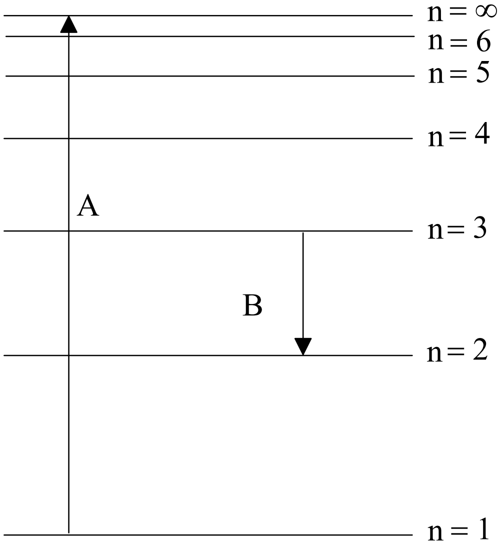
(ii) P^{3-} has one more shell than Si^{4+};
some justification in terms of electron loss / gain;
net attractive forces; ***[2 max]***

(iii) same electron arrangement / both have two complete shells;
extra protons in Na^{+} (attract the electrons more strongly); ***[2]***

(b) Na and F (*accept names, need both for* ***[1]***) / NaF / $Na^{+}F^{-}$;
largest difference in electronegativity; ***[2]***

(c) Al_2O_3;
amphoteric; ***[2]***

2.



(i) line starting at n = 1;
line finishing at n = ∞ (*not above* ∞);
upward arrow; ***[2 max]***
3 correct ***[2]****, 2 correct* ***[1]****.*

(iii) Line from n = 3 to n = 2;
Arrow pointing downward (*in any transition*); ***[2]***

(b) (i) 1p
2n
1e^- ;

p, n in nucleus
e^- orbiting / outside ; ***[2]***

[1] *for number and type of particles and* ***[1]*** *for location.*

(ii) $N_2 + 3T_2 \rightarrow 2NT_3$;
Correct formulas ***[1]****, balancing of correct equation* ***[1]****.*

$2Na + 2T_2O \rightarrow 2NaOT + T_2$; ***[4]***

Correct formulas ***[1]****, balancing of correct equation* ***[1]****.*
If H is used instead of T in any of the equations ***[3 max]****.*
Accept any other suitable equation for both parts.

3. (a) A;
E; *[2]*
*If 3 choices shown **[1 max]**, if 4 choices shown **[0]**.*

(b) (i) after 15s (product) $= 0.37\ (\text{mol dm}^{-3})$;
$\text{rate} = \dfrac{0.37}{15} = 0.025$;
2 sig figs – if penalized here do not penalize in Q6 (c) (iv) or Q8 (d) (ii)
$\text{mol dm}^{-3}\ \text{s}^{-1}$ / M s^{-1} / $\dfrac{\text{M}}{\text{sec}}$; *[3]*

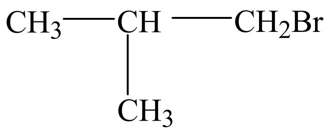
(ii) at equilibrium / rates of forward and reverse reactions are equal / $\Delta G = 0$; *[1]*

4. (a) molecules become larger / heavier / have higher $M_{(r)}$ values / number of electrons increases;
van der Waals' / London / dispersion forces increase; *[2]*

(b) hydrogen bonding **between molecules** (in H_2O);
this bonding is stronger (*must be implied comparison with (a)*); *[2]*

5. (a) change / replacement of **atom** / **group** (in molecule);
by species with a non-bonding / lone pair of electrons / attracted to electron deficient part of molecule *(OWTTE)* / Lewis base; *[2]*

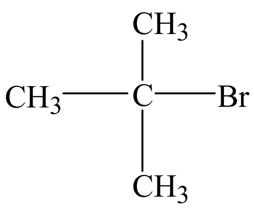
(b) (i) CH_3—CH_2—CH_2—CH_2Br /



[1]

(ii) CH_3—CH_2—$CHBr$—CH_3 *[1]*

(iii)



[1]

Position of Br must be clearly shown
In (i), (ii) and (iii), all C—C bonds must be shown. Do not penalize missing H atoms.

(c) (i) $(CH_3)_3CBr \rightarrow (CH_3)_3C^+ + Br^-$;

$(CH_3)_3C^+ + OH^- \rightarrow (CH_3)_3COH$; ***[2]***

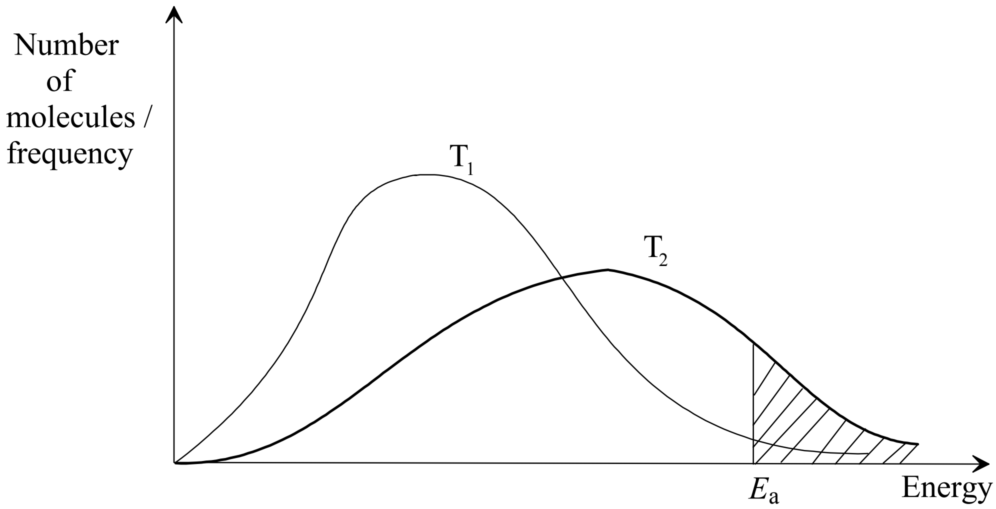
Equations must be balanced.
ECF unlikely from first equation.

(ii) molecularity = number of reactant molecules / species in a particular step / RDS / slowest step;
rate determining step = slowest step; ***[2]***

(iii) step 1 *(however identified)*; ***[1]***
ECF possible if chosen reaction is bond-breaking

SECTION B

6. (a) (i)



both axes correctly labelled;
T_2 peak / lower;
and to right of T_1; ***[3]***
Area under graph is not important.

(ii) rate increased / changes;
as more molecules with $\geq E_a$; ***[2]***
No explicit reference to graph required.

(b) (i) rate increased / changes;
activation energy / E_a lowered;
catalyst provides alternative route / more molecules have $E \geq E_a$; ***[3]***

(ii) heterogeneous: different state / phase from reactants;
homogeneous: same state as reactants; ***[2]***

(iii) any suitable example, *e.g.* MnO_2 for H_2O_2 for decomposition (heterogeneous);
e.g. $2H_2O_2 \rightarrow 2H_2O + O_2$;
H_2SO_4 / H^+ for ester production (homogeneous);
e.g. $CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$; ***[4]***

(c) (i) the power of a reactant's concentration in the rate equation / sum of powers of concentration / rate $= k[X]^n$, where n = order of reaction; ***[1]***
Must be in terms of powers of concentration.

(ii) experiment 1—2 : [X] doubles and rate × 4;
2nd order for X;
experiment 2—3 : [Y] doubles and rate × 2;
1st order for Y; ***[4]***

(iii) rate $= \mathrm{k}[X]^2[Y]$ (*ECF from (ii)*);

for experiment 1, $1.0 \times 10^{-2} = \mathrm{k}(0.25)^2(0.25)$;
$\mathrm{k} = 0.64$;
$\mathrm{mol^{-2}\,dm^6\,s^{-1}}$; ***[4]***
Allow ECF from rate expression.

(iv) $\mathrm{rate} = 0.64[0.40]^2[0.60]$;
$= 0.061$; ***[2]***
Final answer to 2 sig figs only. Do not penalize if already penalized in 3 (b) (i).
Allow ECF from (iii).

7. (a) (i) ionic conductor / allows movement of ions between electrolytes / completes circuit; ***[1]***

(ii) $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^{-}$ *(state symbols not needed)*; ***[1]***

(iii) 298 K / 25 °C, 1 atm / 1.01×10^{5} Pa, 1 mol dm^{-3} solutions; ***[2]***
(*all 3 for **[2]**, 2 for **[1]***)

(iv) $0.34 - (-0.76) = 1.10$ V; ***[2]***
***[1]** for finding correct data, **[1]** for answer with unit (ECF).*

(v) decreases;
Cu^{2+} ions are converted to Cu metal / Cu deposited on electrode; ***[2]***
Allow ECF from (iv).

(vi) Cu deposited on Zn rod / rod goes pink / brown;
blue colour of solution $\rightarrow$ paler;
gets hotter / temperature increase / exothermic; ***[2 max]***

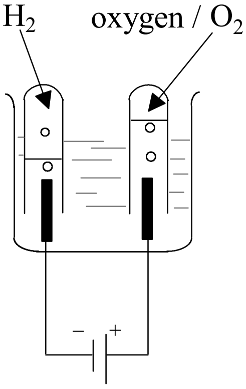
(b) (i) Ti^{2+} (*no ECF to explanation*);
Ti^{2+} has greatest tendency to lose electrons / Ti^{3+} has least tendency to gain electrons; ***[2]***

(ii) $Ce^{4+}(aq) + Ti^{2+}(aq) \rightarrow Ce^{3+}(aq) + Ti^{3+}(aq)$; ***[2]***
***[1]** for equation, **[1]** for state symbols. If wrong equation is given, award **[1]** for state symbols.*

(iii) $\Delta G^{\ominus}$ negative;
reaction spontaneous / corresponds to positive cell potential; ***[2]***
*Positive **[0]**, non-spontaneous **[1]**.*

(c) (i) (aqueous) sodium hydroxide / dilute sulfuric acid / sodium sulfate; ***[1]***
Accept correct formulas.
*Any combination of K^{+} / Na^{+} / H^{+} and NO_3^{-} / SO_4^{2-}. Halides **not** acceptable.*
(*"water" is not a solution*)

(ii)



Or similar suitable diagram.
gas collection method;
names of gases correct way round at electrodes;
2:1 volume ratio correct way round; ***[3]***

(d) (i) mass increases;
copper deposited;
because X is negative and attracts Cu^{2+} ions / reduction occurs at X /
$Cu^{2+} + 2e^{-} \rightarrow Cu$; ***[3]***

(ii) increase time;
increase current; ***[2]***

8. (a) $pH = -\log_{10}[H^+]$; ***[1]***

(b) (i) acidic;
$Fe(H_2O)_6^{3+}$ is a weak acid / Fe^{3+} reacts with OH^- / equation to show formation of HCl or H^+; ***[2]***
"*$FeCl_3$ is acidic*" *is not acceptable.*

(ii) neutral;
$NaNO_3$ / sodium nitrate is formed from strong base and strong acid / ions do not hydrolyse; ***[2]***

(iii) alkaline;
As CO_3^{2-} is weak base / combines with H^+ / equation showing formation of OH^-; ***[2]***
Acidic, neutral, alkali mark in each case is independent of reason.

(c) (i) 8.7 ± 0.7;
low $[H^+]$ thus small addition of OH^- has great effect / OH^- increases rapidly as NaOH is a strong base / logarithmic nature of pH; ***[2]***

(ii) volume of NaOH $= 8.2\ cm^3$ (*exact*);
amount of NaOH $= \dfrac{8.2}{1000} \times 0.1 = 0.00082\ mol$;
$[HA] = \dfrac{0.00082}{0.010} = 0.082\ mol\ dm^{-3}$ / 0.082 M; ***[3]***
*Correct answer **[3]**, units needed for last mark.*

(iii) correct pH reading from graph (2.9) *(allow 2.8 or 3.0)*;
thus $[H^+] = 1.26 \times 10^{-3}\ (mol\ dm^{-3})$;
$K_a = \dfrac{10^{-2.9} \times 10^{-2.9}}{0.082}$;
$= 1.9 \times 10^{-5}\ (mol\ dm^{-3})$;
$pK_a = 4.71$ ***[5]***
Accept 4.7 and allow ECF from (ii).

If pH given as 2.8, $K_a = 3.06 \times 10^{-5}$ and $pK_a = 4.51$
If pH given as 3.0, $K_a = 1.22 \times 10^{-5}$ and $pK_a = 4.91$

If half equivalence method used:
volume $= 4.1\ cm^3$
$pK_a = 4.75$
*Award **[2]** out of last **[4]**.*

(d) (i) a solution that resists pH change / maintains a (nearly) constant pH;
when **small** amounts of acid or alkali are added; ***[2]***

(ii) M_r of sodium ethanoate;

moles of sodium ethanoate $= \frac{0.25}{82} = (0.0030)$;

$[CH_3COO^-] = \frac{0.0030}{0.2} = 0.015 \ (\text{mol dm}^{-3})$ *2 sig figs only*; ***[3]***

Do not penalize if already penalized in 3 (b) (i) or 6 (c) (iv).

(iii) $K_a = \frac{[H^+]\,[CH_3COO^-]}{[CH_3COOH]}$ *(or with substituted values)*;

May be assumed from later work.

$[H^+] = \frac{10^{-4.76} \times 0.10}{0.015} = (1.159 \times 10^{-4})$;

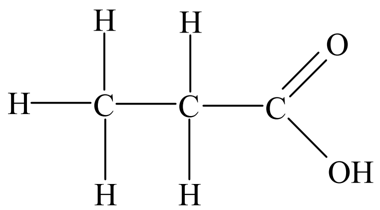
pH = 3.9(4); ***[3]***

Allow ECF throughout (d) (ii) and (iii).

9. (a) (i) 74; ***[1]***

(ii) $29 = C_2H_5^+$ / CHO^+ ;
$45 = COOH^+$;
$57 = C_2H_5CO^+$ / $C_2O_2H^+$ **not** $C_4H_9^+$; ***[3]***
If no + sign shown, penalize once only.

(iii) *Omitted H atom(s) – penalize once on whole question.*



Must be fully correct

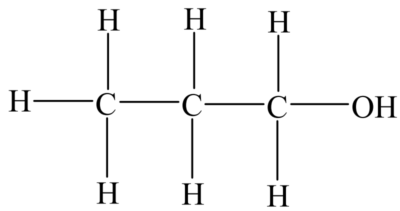
or C_2H_5COOH / $C_2H_5CO_2H$ / CH_3CH_2COOH ; ***[1]***

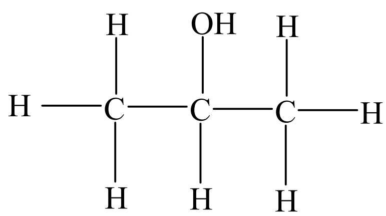
(b) (i)

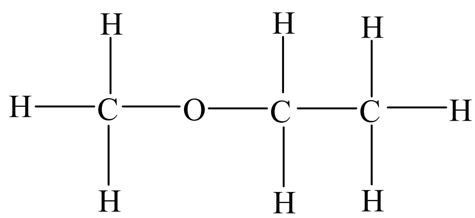
C	H	O
$\frac{60}{12}$	$\frac{13.3}{1}$	$\frac{26.7}{16}$;

empirical formula C_3H_8O ;
molecular formula C_3H_8O ; ***[3]***

(ii)





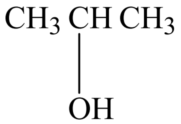


[3]

[1] *for each formula.*
Accept $CH_3CH_2CH_2OH$, $CH_3CH(OH)CH_3$ *and* $CH_3OCH_2CH_3$.
Incorrect structure must have $M_r = 60$ *and all bonding complete to be considered for ECF. An alternative is isomers of ethanoic acid.* ***[1]***

(iii) two compounds contain OH / one isomer does not contain OH; ***[1]***

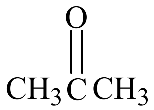
(iv) $CH_3CH_2CH_2OH$ 4 peaks; ***[2]***



3 peaks;

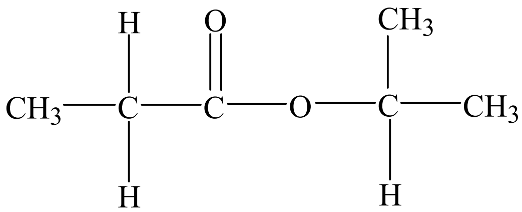
*Allow **[1]** for different number of peaks / different ratio of peaks.*
*Allow **[1]** for chemical shift for OH in appropriate range.*
Allow ECF from (b)(ii) for number of peaks.

(c) C: $CH_3CH(OH)CH_3$
propan-2-ol;

D:  ; / CH_3COCH_3 ***[4]***
propanone / acetone;

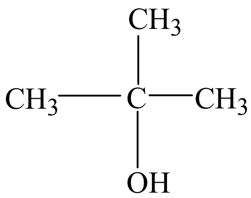
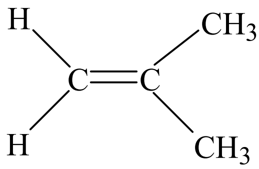
If displayed formula given, double bond must be shown from C to O.
In each case, allow ECF for name if wrong structure is given.

(d)

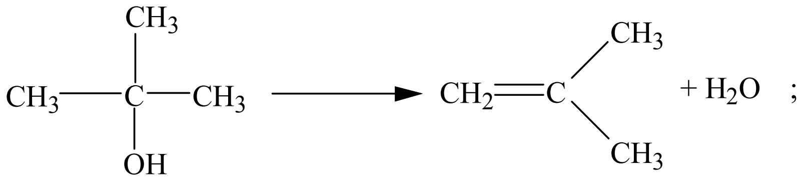


[1]

Accept $CH_3CH_2COOCH(CH_3)_2$. *Allow ECF.*

(e) (i) E:  ; F:  ;

(2)-methylpropan-2-ol (*ECF*); methylpropene; ***[4]***
Accept $(CH_3)_3COH$ *and* $CH_2C(CH_3)_2$. *Must be consistent with alcohol.*
Allow ECF for names, i.e. must be consistent with structures.

(ii) 

Previous formulas from (e)(i) + H_2O as product.

dehydration / elimination; **[2]**

Do not accept condensation.