N09/4/CHEMI/SP3/ENG/TZ0/XX/M+

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MARKSCHEME

November 2009

CHEMISTRY

Standard Level

Paper 3

20 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) by e-mail (or telephone) – if by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader by e-mail at any time if they have any problems/queries during the marking process.

Note:

The DHL courier service must be used to send assessment material to your team leader/senior moderator and to IB Cardiff. (However, this service is not available in every country.) The cost is met directly by the IBO. It is vitally important that the correct DHL account number is used.

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

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1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

3. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases write a brief annotation to explain your decision. You are encouraged to write comments where it helps clarity, especially for moderation and re-marking. It should be remembered that the script may be returned to the candidate.

4. Unexplained symbols or personal codes/notations are unacceptable.

5. Record marks in the right-hand margin against each mark allocation shown in square brackets *e.g.* ***[2]***. The total mark for a question must equal the number of ticks for the question.

6. Do **not** circle sub-totals. **Circle the total mark** for the question in the right-hand margin **at the end of the question.**

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

8. Where work is submitted on additional sheets the marks awarded should be shown as ticks and a note made to show that these marks have been transferred to the appropriate square bracket in the body of the script.

9. 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 on the cover sheet.

10. 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 cover sheet. **All scripts are checked and a note of all clerical errors will be given in feedback to examiners.**

11. If an answer extends over more than one page and no marks have been awarded on a section draw a diagonal line through that section to indicate that it has been marked.

12. If a candidate has attempted more than the required number of questions within a paper or section of a paper, mark all the answers and use the marks of those answers that have the highest mark, **unless the candidate has indicated the question(s) to be marked on the front cover**.

13. A mark should not be awarded where there is contradiction within an answer. Make a comment to this effect in the left hand margin.

Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options **[2 × 20 marks]**. Maximum total = **[40 marks]**.

1. A markscheme often has more marking points than the total allows. This is intentional. Do not award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified by means of a semicolon (;).

3. An alternative answer or wording is indicated in the markscheme by a slash (/) - either wording can be accepted.

4. Words in brackets ( ) in the markscheme are not necessary to gain the mark.

5. Words that are underlined are essential for the mark.

6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.

7. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing ***OWTTE*** (or words to that effect).

8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

9. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing –**1(U)** at the first point it occurs and **U** on the cover page.

11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by writing –**1(SD)** at the first point it occurs and **SD** on the cover page.

12. 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.

13. 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 directed otherwise in the markscheme.

14. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option A — Modern analytical chemistry

A1. (a) (i) radiowaves; ***[1]***

(ii) IR / infrared; ***[1]***

(b) HCl;
vibration/stretching of bond/molecule produces a <u>change</u> in dipole moment/polarity; ***[2]***
Do not accept contains a polar bond.
Ignore reference to bending.
M2 cannot be awarded for incorrect choice of molecule.
Accept explanation of why O_2 and H_2 do not absorb IR.

A2. (a) (i) 88;
Do not award mark if units are given.
$C_4H_8O_2^+$; ***[2]***

(ii) $CH_3CH_2^+$/$C_2H_5^+$ / CHO^+; ***[1]***
Only penalize once for missing charge in (a) (i) and (ii).

(iii) $C_2H_3O_2$ produced has no charge / fragment produced after loss of C_2H_5 from molecular ion has no charge; ***[1]***
Accept fragment(s) too unstable, fragment breaks up etc.
Do not accept answers with reference to $^{13}C/^{14}C$ isotopes and peak at m/z = 61.
Do not accept $C_2H_3O_2^+$ / $C_3H_7O^+$ does not exist.

(b) (i) *A*: C=O **and** *B*: C–O; ***[1]***
No mark if two bonds are given for A or B.
Ignore names if incorrect.

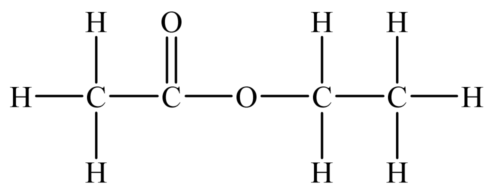
(ii) ester; ***[1]***
Do not accept COO.

(c) (i) the number of different <u>hydrogen/proton</u> environments / *OWTTE*; **[1]**

(ii)

Peak	Chemical shift / ppm	Relative peak
First	20	3
Second	4.1	2
Third	0.9 –1.0;	3;

[2]

(iii)  / $CH_3CO_2CH_2CH_3$; **[1]**

A3. (a) (i) $\dfrac{\text{distance moved by solute}}{\text{distance moved by solvent}}$ / ratio of distances moved by solute and solvent / *OWTTE*; **[1]**

Accept sample/substance/compound/component for solute.

(ii) *R_f of A*:

$\left(\dfrac{7.5-7.7}{8.0}=\right)0.93-0.96$;

R_f of B:

$\left(\dfrac{6.0}{8.0}=\right)0.75\,/\,0.74$ **and** banned substance $=$B; **[2]**

Penalise if units are given for f R_f of A and B only once.

(iii) different number of spots/R_f values / *OWTTE*; **[1]**

Do not accept solvent moves different distances.

Accept spots move different (relative) distances/OWTTE.

(b) *Paper chromatography*:

water (in the fibres of the paper);

Do not accept just paper.

Column chromatography:

alumina/Al_2O_3/aluminium oxide / silica (gel)/SiO_2/silicon dioxide; **[2]**

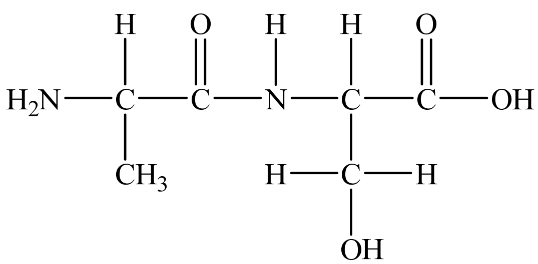
Option B — Human biochemistry

B1. (a) $H_2NCHRCOOH$; ***[1]***

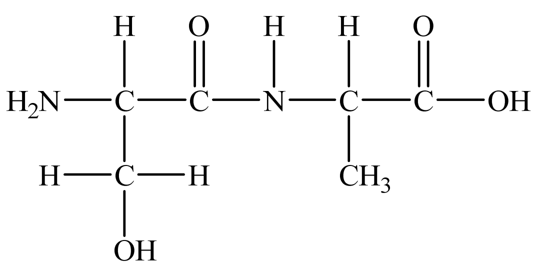
Allow various other combinations e.g. $RCH(NH_2)COOH$ etc. and allow NH_2 and HOOC on right etc.
Allow structural formula if drawn, showing all the bonds.
Do not accept the formula of a specific amino acid.

(b) isoelectric point;
formation of zwitterion/inner salt/ $H_3N^+CHRCOO^-$;
(can act as a) buffer / has both acidic and basic properties / can react with H^+ or OH^- / can exist as cations in acidic solution **and** anions in alkaline solution;
can form proteins/dipeptides/peptides / can react to form condensation products; ***[2 max]***

(c)



;



;

Allow condensed structural formulas.

water/ H_2O ; ***[3]***

(d) (i) *Primary structure:*
(linear) sequence/order of amino acids / *OWTTE*;

Secondary structure:
way in which chain of amino acids folds itself / way in which sequence is kept together by hydrogen bonding between atoms in sequence / *OWTTE*; ***[2]***
Accept can exist as α-helix or β-sheet.

(ii) hydrogen bonding/ H- bonding; ***[1]***

(e) add hydrochloric acid/HCl / hydrolyse to convert protein into amino acid mixture / (successively) release amino acids;
mixture/amino acids spotted/placed on paper/gel;
Can be shown with diagram.
Do not accept protein placed/spotted on paper/gel.

use of buffer solution;
apply voltage/potential difference;
Can be shown with diagram.
Do not allow "pass current/electricity through mixture".

amino acids move in different directions (depending on their isoelectric points);
develop with ninhydrin/triketohydrindane hydrate/2,2-dihydroxyindane-1,3-dione/ organic dye;
measure distances moved / compare with known samples / measure isoelectric points (and compare with data); ***[5 max]***

B2. (a) micronutrients are substances required in small/trace amounts/<0.005% body weight **and** macronutrients are substances required in large amounts/>0.005% body weight;

Example of a micronutrient:
vitamins / metals / minerals / Fe / Cu / F / Zn / I / Se / Mn /Mo / Cr / Co / B;
Allow correct names e.g. selenium etc.
Allow specific vitamins.

Example of a macronutrient:
proteins / fats / lipids / carbohydrates / metals / (some) minerals / Na / Mg / K / Ca / P / S / Cl; ***[3]***
Allow correct names e.g. magnesium etc.

Award no marks if the examples are the wrong way around.
Do not award mark if more than one example is provided and one is incorrect.

(b) (vitamin) C/ascorbic acid;
more/many/several hydroxyl/OH groups that can form hydrogen bonds (with water); ***[2]***
M2 cannot be awarded for incorrect vitamin.

(c) scurvy / wounds failing to heal / bleeding gums; ***[1]***

Option C — Chemistry in industry and technology

C1. (a) (i) it lowers the operating temperature/melting point (of alumina) / it saves heat/energy / improves conductivity / acts as a solvent; ***[1]***
Do not accept lowers melting point of aluminium.
Do not accept "lowers boiling point".

(ii) $Al(l)^{3+} + 3e^{-} \rightarrow Al(l)$; ***[1]***
Ignore state symbols.
Accept e instead of e^{-}.

(iii) carbon dioxide / carbon monoxide / fluorine / tetrafluoromethane; ***[1]***
Do not accept formulas since the name is asked for specifically.

(b) (i) high/good (electrical) conductivity **and** low density; ***[1]***
Do not accept lighter.
Accept malleable/ductile/resistant to (further) corrosion as one property.
Reference to high/good conductivity ***or*** *low density needed.*

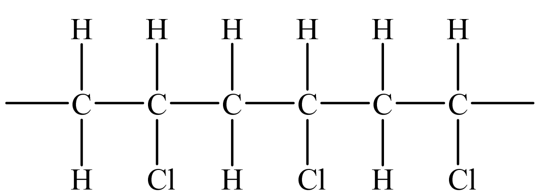
(ii) in alloy different sized/Ni atoms/ions/particles disrupt regular structure;
stops layers from slipping/sliding / *OWTTE*; ***[2]***
Do not accept "stop layers moving".
Accept diagrams if explanation clear.

C2. (a) C–Cl bond / molecule is polar;
stronger intermolecular/van der Waals'/London/dispersion forces/dipole-dipole attraction; ***[2]***

(b) addition of plasticizers;
Allow misspelling within reason.

get between polymer chains / keeps chains further apart **and** reduces attraction (between the chains); ***[2]***

(c)



; ***[1]***

Accept any structure with all the Cl atoms shown on the same side.
Continuation bonds at end of structure not needed.
Hydrogen atoms must be included.

C3. (a) walls have rolled/single sheets of graphite/carbons bonded in hexagons;
ends have half a buckyball (fullerene)/carbons in pentagons (and hexagons); ***[2]***

(b) covalent bonds are very strong; ***[1]***

(c) (i) large surface area;
Do not accept "reactive surface".

high selectivity related to dimensions of tube; ***[2]***

(ii) unknown health effects; ***[1]***
Accept potentially harmful as easily ingested/inhaled.
Accept difficulty of preparing nanotubes in required amounts.

C4. (a) $0 \rightarrow +2$ / increase by 2;
negative; ***[2]***
If decrease by 2, positive, award ***[1]***. *If decrease by 2, negative, award* ***[0]***.

(b) insoluble (Cd^{2+} ions do not escape into solution); ***[1]***
Do not accept solid.

Option D — Medicines and drugs

D1. (a) (i) *Fleming:*
discovered penicillin inhibited growth of/kills/destroys bacteria/ has antibiotic properties;

Florey and Chain:
isolated/purified/extracted penicillin / produced penicillin in large/bulk quantities / *OWTTE*; ***[2]***
Accept "cured/relieved septicaemia in humans"

(ii) interfere with cell wall formation (in bacteria) / prevent formation of cross-links within cell wall;
Accept "destroys cell wall".
size/shape of cell cannot be maintained / water enters the cell / osmosis occurs / cell bursts/disintegrates; ***[2]***

(b) (i) benzene/aromatic ring/ C_6H_5 /phenyl;
Accept the circle-in-hexagon or Kekule symbols
Do not allow benzene or arene.

amine/ NH_2 / amino; ***[2]***
Do not award mark if reference to secondary/tertiary given.

(ii) to overcome the resistance that bacteria develop to existing antibiotics / increases resistance to penicillinase enzyme / *OWTTE*;
Do not accept "over prescription".

prevents penicillinase enzyme from destroying penicillin / molecules have different shape/stability/solubility/side-chain / *OWTTE*; ***[2]***

D2. (a) (i) an effect produced in addition to the one intended / unwanted/undesired effect; ***[1]***

(ii) range of a drugs concentration (in blood) between effective/ED_{50} and toxic levels/LD_{50} / (Therapeutic Index) $= LD_{50} / ED_{50}$; ***[1]***
Do not accept "difference of drug concentration".

(iii) Therapeutic effect of an inert substance on the body / body is fooled into healing itself naturally / people responding positively to/psychological effect after being given a substance that is not a drug / *OWTTE*; ***[1]***

(b) (i) intravenous / into veins;
transported/pumped via blood (to various parts of body); ***[2]***

(ii) intramuscular/intermuscular/into muscles **and** subcutaneous/into fat; ***[1]***
Allow ***[1]*** *if all three methods are stated in (b) (i) and (ii) but not in correct place.*

(iii) inhalation/breathing it in; ***[1]***

D3. (a) increased heart rate / increased blood pressure / increased breathing rate / dilation of pupils / constriction of arteries / sweating / increased alertness / increased concentration / decreased appetite; ***[1]***

(b) mimics the effect of adrenaline / stimulates the sympathetic nervous system;
contains phenylethylamine (group); ***[2]***
Accept benzene/aromatic ring linked to amine group by carbon chain.

(c) increased amounts needed to produce same effect;
increasing amounts cause damage/death/overdose/lethal dose; ***[2]***

Option E — Environmental chemistry

E1. (a) long wavelength / infrared/IR radiation from Earth's surface (some of this radiation) is absorbed (by gas);
Do not accept "trapped" or blocked.
Do not award mark for "IR from sun".

causes (increased) vibration in bonds;
re-radiates heat back to the Earth; ***[2 max]***
Accept "re-transmits"
Do not accept "reflects/bounces".

(b) melting of polar ice caps/glaciers melting;
thermal expansion of oceans / rise in sea levels / coastal flooding;
stated effect on agriculture (*e.g.* crop yields changed);
changes in flora/plant/fauna/animal/insect distribution/biodiveristy;
Accept specific example.

stated effect on climate (*e.g.* drought / increased rainfall / desertification); ***[3 max]***
Do not accept "climate change" alone.
Do not allow "increased temperature/global warming" (given in question).

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

E2. (a) amount of oxygen needed to decompose organic matter (in water sample);
in a specified time/five days / at a specified temperature/ 20°C; ***[2]***

(b) secondary (treatment) / second stage / activated sludge (process);
organic matter oxidized by bacteria/microorganisms; ***[2]***
Reference to both oxidation and bacteria/microorganisms needed.
No ECF.

(c) increase plant growth due to added nutrients;
oxygen concentration reduced by plant decay / plants decomposed aerobically; ***[2]***
Allow eutrophication as an alternative to one of the above.

E3. C/soot/particulates/hydrocarbons/VOC;
$NO/NO_2/NO_x$;
$SO_2/SO_3/SO_x$; ***[1 max]***
*Award **[1]** for any two.*
Accept names or formula.
Do not accept N_2O.

C/soot/particulates/hydrocarbons/VOC produced by incomplete combustion;
NO/NO_x produced by high temperature combination of (nitrogen and oxygen);
$SO_2/SO_3/SO_x$ produced from sulfur impurities in diesel; ***[2 max]***
*Award **[1]** each for any two.*

E4. (a) *Landfill*:
can be used to deal with large volumes/amounts / filled ground can be re-used / low cost;
Do not accept "no air pollution".

Incineration:
reduces volume / requires minimal space / source of energy; ***[2]***
Do not accept "no land pollution"
Apply list principle i.e. award ***[0]*** *when one correct and one incorrect advantage given.*

(b) limited supply of oxygen (prevents the bacteria from acting); ***[1]***
Do not accept air.

(c) high-level waste has longer half-life / low-level waste has shorter half-life;

high-level waste is vitrified/made into glass/buried underground/in granite/in deep mines/under water/in steel containers/in cooling ponds / *OWTTE*;

low-level waste is stored under water/in steel containers/in cooling ponds/filtered/discharged directly into sea / *OWTTE*; ***[3]***
Accept cooling ponds/steel containers/under water/concrete containers only once.

Option F — Food chemistry

F1. (a) provides energy;
enables growth;
replaces chemicals for maintenance and repair of body tissue; ***[1 max]***
Do not accept "prevents deficiency diseases."

(b) (i) (tri)esters/contains COO group/(tri)glycerides;
(three) fatty acid chains joined to glycerol/propan-123-triol */ OWTTE*; ***[2]***
Accept long-chain carboxylic acid and glycerine.

(ii) empirical formula is CH_2O / general formula is $C_nH_{2n}O_n$;
contains one carbonyl/C=O group **and** at least two/several hydroxyl/OH groups; ***[2]***

(c) four C=C bonds in arachidonic acid **and** three C=C bonds in linolenic acid / greater unsaturation/number of C=C bonds in arachidonic acid;
presence of double bonds prevents close-packing/kinks in structure / extra double bond decreases ability of arachidonic acid molecules to align themselves together / *OWTTE*;
(so) van der Waals'/London/dispersion/intermolecular forces weaker in arachidonic acid; ***[3]***

F2. (a) a GM food is derived/produced from a GM organism; ***[1]***

(b) *Benefits:* ***[2 max]***
enhanced taste/quality/flavour;
reduced maturation time;
increase in nutrients/yield;
improved resistance to disease/pests/herbicides;
bio-herbicides and bio-insecticides that do not harm the environment can be used;
conservation of soil/water/energy;

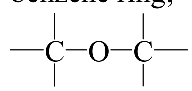
Potential concern: ***[1 max]***
links to increased allergies (for people involved in their processing);
risk of changing composition of a balanced diet by altering natural nutritional quality of foods;
concern about genetic pollution from crops used to produce them; ***[3 max]***

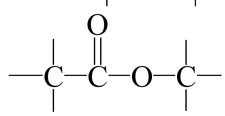
F3. (a) (i) time when quality of a food no longer matches customer expectations (because of a change in a key feature such as flavour, odour, texture and appearance *etc*.) / *OWTTE*; ***[1]***
Reference to "customer expectations" needed.

(ii) substance that delays onset/slows (rate of) oxidation (of food); ***[1]***
Do not accept "prevents".

(b) all contain phenol/phenolic functional group/a benzene ring with attached OH group;
Accept all have a benzene ring.

both 3-BHA and BHT contain at least one t-butyl/tertiary butyl group/ $-C(CH_3)_3$ / have alkyl/R/CH groups joined to benzene ring;

3-BHA contains an ether group /  ;

PG contains an ester group /  ;

[4]

(c) *Antioxidant:*
vitamin C/ascorbic acid / vitamin E/tocopherols/TCP / carotenoids/β carotene / selenium / rosmarinic acid / gallic acid / anthocyanins / curcumin / flavanoids/catechins;

Long-term health benefit:
reduce risk of cancer/heart disease (inhibiting the formation of free radicals); ***[2]***
Do not accept "prevents scurvy".

Option G — Further organic chemistry

G1. (a) dimethylamine / $(CH_3)_2NH$; ***[1]***

(b) methyl groups electron-donating/electron-releasing/ involve positive inductive effect;
stabilization of positive ion / so dimethylamine contains a N-atom that is more electron-rich;
more likely to attract/accept proton from water molecule; ***[2 max]***
No ECF from (a).

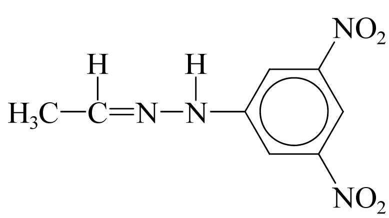
G2. (a) electronegative/electron-withdrawing chlorine draws electrons away from carboxylate/ COO^-/CO_2^- (group) / attracts electrons in the OH bond closer to oxygen;
making conjugate base weaker (and hence making the acid stronger) / reduces electron density on oxygen / so making it easier for a proton to leave; ***[2]***

(b) $CH_3Cl + Mg \rightarrow CH_3MgCl$;
$CH_3MgCl + CO_2 \xrightarrow{H_2O} CH_3COOH + Mg(OH)Cl$;
H_2O required for mark

OR

$CH_3Cl + NaCN \rightarrow CH_3CN + NaCl$;
$CH_3CN + H_2O + H_3O^+ \rightarrow CH_3COOH + NH_4^+$; ***[2 max]***
Allow any other reasonable pathway.

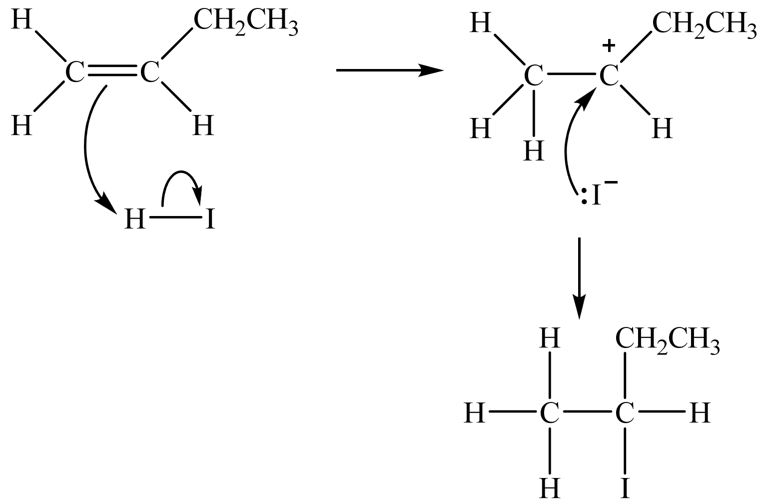
G3. (a) (i) **A:** $CH_3CH_2C(CH_3)_2OH$; ***[1]***

(ii) **C:** 

; ***[1]***

(b) addition-elimination / condensation; ***[1]***

G4. (a)

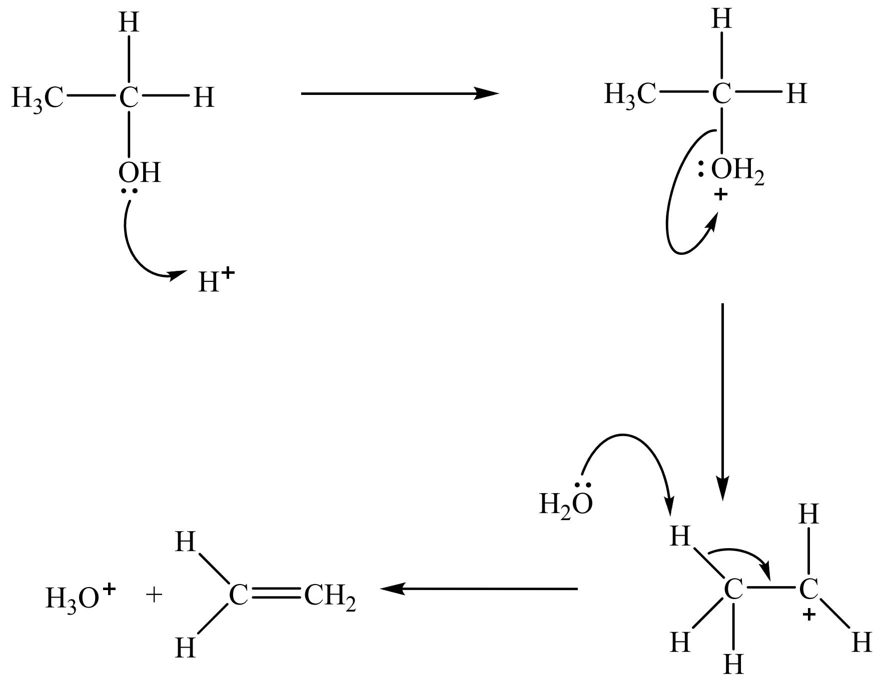


curly arrow from C=C to H of HI **and** curly arrow showing iodide leaving;
structure of carbocation **and** iodide attacking carbocation from either lone pair or negative charge;
Allow $CH_3C^+HCH_2CH_3$.

structure of $CH_3CHI(CH_2CH_3)$ as major organic product (**C**);

secondary/2° carbocation more stable than primary/1° carbocation;
because it is stabilized by a greater number of electron-releasing alkyl groups; ***[5]***
*Award **[3 max]** for a correct mechanism involving the formation of the 1-iodo product.*

(b)



curly arrow showing lone pair on oxygen attacking H^+;
curly arrow showing departure of water;
Allow no charge on O.
Do not allow departure of OH^-.

formula/structure of carbocation;
Allow condensed formula if + charge on correct C atom

curly arrow showing lone pair of oxygen on water attacking hydrogen / curly arrow from C–H bond to form C=C / curly arrow showing $H_2PO_4^{2-}$ removing hydrogen;

Product D: $CH_2{=}CH_2$; ***[5]***

Only penalise once for missing lone pair on O.
For M4, allow other alternatives such as $H_2PO_4^{2-}$ ion removing H^+ (which shows its action as a catalyst) or simple loss of H^+.

e.g.