



MARKSCHEME

November 2011

CHEMISTRY

Standard Level

Paper 3

21 pages

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Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options [**2 x 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 shown 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 **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. When marking, indicate this by adding **ECF** (error carried forward) on the script.
10. Do not penalize candidates for errors in units or significant figures, unless it is specifically referred to in the markscheme.
11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the markscheme, similarly, if the formula is specifically asked for, unless directed otherwise in the markscheme do not award a mark for a correct name.
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13. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option A — Modern analytical chemistry

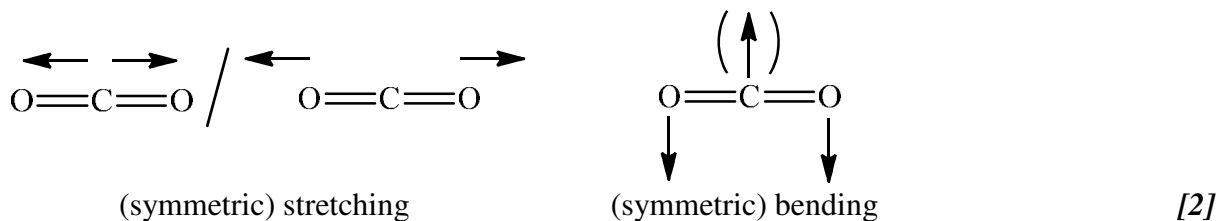
- A1. (a)** *UV:*
 electronic transitions;
Microwave:
 molecular rotation; [2]

- (b) (i) a light source using the same element as metal ions being detected;
 (metal) atoms absorb light/heat when excited (when sample injected into flame);
 electrons excited from lower to higher energy levels;
 metals have characteristic wavelengths/frequencies (of absorption);
 absorbance/absorption is proportional to concentration of metal (ion); [3 max]

- (ii) *Any two for [1]:*
 Mg/Al/Cu/Na/K in blood (serum)
 Hg/Cu in alloys
 Cu in water from Cu pipes
 Ba/Cd/Cr/Mn/Pb/Zn/Hg/named heavy metal in (sea) water
 Al/Fe in plants / soil
 Pb in paint
 Mg (for hardness) in water [1 max]
Answer must identify metal (ion) and where it is present for mark.

- (iii) use solutions of known concentrations/standard solutions to obtain calibration curve;
No mark for just: draw/obtain calibration curve.
 determine concentration of metal (ion) from calibration curve/absorption values; [2]
Award [1 max] for stating from/using calibration curve without any explanation.

- A2. (a)**



Award [1] for stretching and bending without diagrams.
Award [1] for clearly illustrated diagrams without mention of stretching and bending.
Do not penalize if single lines drawn between atoms.

- (b) change in dipole moment/(molecular) polarity leads to IR absorption / OWTTE;
 symmetric stretching is IR inactive;
 asymmetric stretching/(symmetric) bending is IR active; [3]

A3. (a) *Similarities: [2 max]*

both have two peaks;
in the same/1:3 ratio;
both have only singlet peaks;

Difference:

CH_3COOH will have an absorption/chemical shift/ δ in the range 2.0–2.5,
(HCOOCH_3 will not) / HCOOCH_3 will have an absorption in the range 3.8–4.1,
(CH_3COOH will not) / CH_3COOH will have an absorption in the range 9.0–13.0,
(HCOOCH_3 will not);

[3]

(b) CH_3COOH :

peak at 45 due to $(\text{COOH})^+$ / $(M_r - 15)^+$ due to loss of CH_3 ;

HCOOCH_3 :

peak at 31 due to $(\text{OCH}_3)^+$ / $(M_r - 29)^+$ due to loss of HCO/CHO / peak at 29 due
to $(\text{HCO})^+ / (\text{CHO})^+ / (M_r - 31)^+$ due to loss of OCH_3 ;

[2]

Penalize missing + sign once only.

Brackets not required around fragments for marks.

(c) protons in water/lipid/carbohydrates (within cells) can be detected by MRI / cells
have different water to lipid ratios / protons in water have different chemical
environments/give different signals;

Accept protons detected by MRI.

gives a (3D) view/image of organs (in body) / *OWTTE*;

[2]

Option B — Human biochemistry

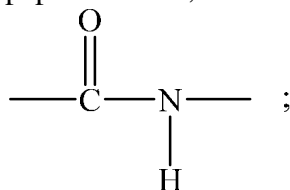
B1. $q = [m \times c \times \Delta T]_{\text{water}} + [C \times \Delta T]_{\text{glass}} = [100.00 \times 4.18 \times 9.4] + [90.2 \times 9.4] \text{ (J)} ;$
 $= [3929.2 + 847.88] / 4777.08 \text{ (J)} ;$
 energy value $= \frac{[4777.08 \times 100]}{5.00} = 95541.6 \text{ (J)} = 95.5 \text{ (kJ)} ;$ **[3]**

Apply ECF as follows:

M1 Likely errors are to omit the CΔT expression or use 5.00 or 105.00 instead of 100.00 for the mass. Either or both of these loses M1 but M2 and M3 can be scored by ECF – examples follow:

<i>M2</i> (omitting CΔT)	(using 5.00 g)	(omitting CΔT and using 5.00 g)
3929.2 (J)	1044.34 (J)	196.46 (J)
<i>M3</i> $\frac{3929.2 \times 100}{5.00} = 78.6 \text{ (kJ)}$	$\frac{1044.34 \times 100}{5.00} = 20.9 \text{ (kJ)}$	$\frac{196.46 \times 100}{5.00} = 3.93 \text{ (kJ)}$

B2. (a) peptide/amide;



Continuation bonds are needed for the mark.

- (b) add HCl/NaOH/enzyme (to hydrolyse the protein into amino acids);
 mixture of amino acids is placed on the centre of a gel/PAGE/polyacrylamide/paper in buffer solution;
 voltage/potential difference applied across gel;
Do not accept electric current.

different amino acids move to different distances according to their charge/isoelectric point / move at different rates towards oppositely charged electrodes;
 gel/paper developed by spraying with ninhydrin/organic dye/can be detected by a stain/made to fluoresce under ultra-violet light;
 distances moved/isoelectric points are compared with literature values;

[4 max]

- B3.** (a) chemical messengers; [1]
- (b) alkene;
ketone; [2]
Accept carbonyl.
Do not accept aldehyde or methyl.
- (c) alcohol; [1]
Accept hydroxyl.
- (d) change release of hormones/FHS/LH (from hypothalamus/pituitary gland);
prevent ovulation/egg release;
prevent attachment of egg to uterus/thin lining of uterus/endometrium;
prevent sperm from reaching egg/thicken cervical mucus; [3 max]
Do not accept "mimic pregnancy".
- B4.** (a) both are polymers of glucose / both contain glycosidic linkages;
starch is formed from α -glucose / can have α -1,6 linkages (and α -1,4 linkages) /
amylopectin form is branched;
cellulose is formed from β -glucose/has β -1,4 linkages / does not have 1,6 linkages /
is not branched / is only straight-chain; [3]
- (b) the enzyme cellulase is absent in humans; [1]

Option C — Chemistry in industry and technology

- C1.** (a) (i) $C(s) + O_2(g) \rightarrow CO_2(g)$; [1]
Ignore state symbols.
- (ii) CO acts as a reducing agent / reaction is endothermic/cooling (this part of) furnace;
 $CO_2(g) + C(s) \rightarrow 2CO(g)$ / $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$; [2]
Ignore state symbols.
- (b) impurities oxidized/reacted with (preheated) oxygen;
 $C + O_2 \rightarrow CO_2$ / $4P + 5O_2 \rightarrow P_4O_{10}$ / $S + O_2 \rightarrow SO_2$ / $Si + O_2 \rightarrow SiO_2$;
Accept description in words.
- (acidic) SiO_2 reacts with (alkaline) CaO/lime/ $CaCO_3$ to form slag/ $CaSiO_3$ /
 $SiO_2 + CaO \rightarrow CaSiO_3$ / SiO_2 /impurities removed/tapped off as liquid slag; [3]
Award [2 max] if no equations given.
- C2.** (a) no other product formed (except HDPE);
 expensive but effective;
 little or no environmental/health impact;
 not easily poisoned by impurities;
 cause (considerable) increase in rate;
 ability to work under mild/severe conditions; [2 max]
- (b) side-chains / branching present (in LDPE);
 limits closer packing / chains further apart / *OWTTE*;
 less van der Waals'/dispersion/London forces / *OWTTE*;
Award mark for less intermolecular forces. Do not accept weaker.
- low(er) melting point (than HDPE); [4]
No mark for different melting point.
Accept reverse argument for HDPE.
- (c) CO_2 is a greenhouse gas / causes climate change / global warming / formation of soot/particulates / melting of polar ice caps / rising sea levels / *OWTTE*; [1]
Accept CO produced is toxic/poisonous.

- C3.** (a) (porous) carbon/graphite electrodes (impregnated) with Pd/Pt/Ag catalysts; [1]
Just Pb/Pt/Ag not sufficient for mark.
- (b) *Positive electrode (cathode):*
$$\text{O}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) + 4\text{e}^- \rightarrow 4\text{OH}^-(\text{aq});$$

Negative electrode (anode):
$$\text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq}) \rightarrow 2\text{H}_2\text{O}(\text{l}) + 2\text{e}^-;$$
 [2]
Ignore state symbols.
Allow e instead of e⁻.
Award [1] if equations are correct but electrodes reversed.
- C4.** (a) no layered arrangement / molecules distributed randomly; [2]
(on average) molecules point in same direction/orientation/directional order;
Accept suitable diagram.
- (b) directional order decreases/is lost / starts to behave like a liquid; [2]
extra energy causes greater movement/overcomes intermolecular forces;

Option D — Medicines and drugs

- D1.** (a) *Any two for [1]*
 alter physiological state/consciousness/activity level/coordination
 alter incoming sensory sensations
 alter mood/emotions **[1 max]**
- (b) (apparent) improvement/therapeutic effect (as a result of taking an inert substance) / *OWTTE*;

Award [1] for any statement below:

body's natural healing process due to individual expectation/desire / power of suggestion / body fooled into healing itself naturally / *OWTTE*;
 used in double blind trials in drug development / (pharmacologically) inert substance used as a control / placebo given to some patients in a drug trial so that effects on other patients who have been given the real drug can be compared / *OWTTE*; **[2 max]**

- D2.** (a) *Moderate dose:*
 (may induce) sedation / soothing / reduce anxiety/tension / drowsiness / slow mental activity / relaxation / sense of well being;
- High dose:*
 induce sleep / coma / unconsciousness / death; **[2]**
Apply general list principle here (if two effects are given for moderate does or high dose and one is correct but the other incorrect no mark awarded).
- (b) (i) $\text{C}_2\text{H}_5\text{OH}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{CH}_3\text{COOH}(\text{aq}) + 4\text{H}^+(\text{aq}) + 4\text{e}^-$; **[1]**
Ignore state symbols.
- (ii) $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{aq}) + 7\text{H}_2\text{O}(\text{l})$; **[1]**
Ignore state symbols.
Allow e instead of e⁻.
- (c) *Any two for [1]*
 GLC/chromatography
 IR
 fuel cells/intoximeter **[1 max]**

- D3.** (a) *Similarity:*
 both contain an amine/phenylethylamine/benzene ring (linked to two carbon atoms attached to N/amine);
No mark for methyl (not a functional group) nor benzene.

Difference:

amphetamine contains primary amine/ -NH_2 / has no OH/hydroxyl/alcohol/phenol groups;

OR

epinephrine/adrenaline contains secondary amine/ -NHCH_3 / OH/hydroxyl/alcohol/phenol groups; [2]

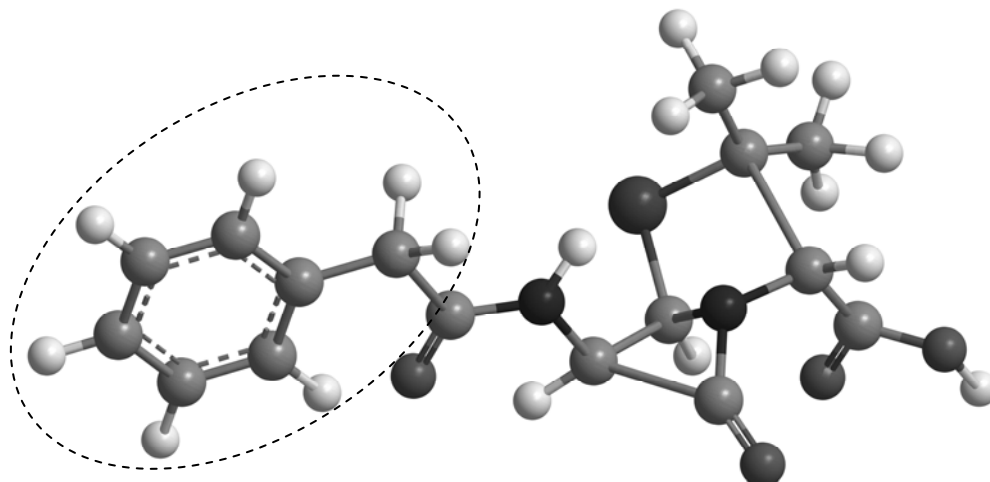
- (b) epinephrine/adrenaline; [2]
 forms hydrogen bonding (with water);
No mark if amphetamine is given as the answer.

- (c) (i) tertiary (amine); [1]
No mark if formula given.

- (ii) basic; [2]
 (lone e^- pair on) N(s) can accept H^+ /proton acceptor / hydrolyses to form OH^- (aq);
No mark if acidic/neutral given as the answer.

- (iii) *Any two for [1]*
 anxiety
 irritability
 sleeplessness/insomnia / increased alertness
 (weak) diuretic/increases urination/urine output
 increased heart rate [1 max]

D4. (a)



[1]

No mark if circle includes CO or just O.

Award [1] if it includes 7 C atoms but misses out on attached H atoms.

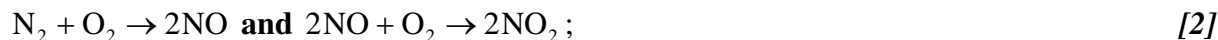
- (b) overprescription can lead to allergic reaction;
 may wipe-out harmless/helpful/beneficial bacteria (in the alimentary canal)/
 destroyed bacteria may be replaced by more harmful bacteria;
 (may pass on genetic) resistance/immunity;
[1] each for any two.

modify R group/side chain to change penicillin effectiveness / form penicillin that
 is more resistant to penicillinase enzyme;

[3 max]

Option E — Environmental chemistry

- E1.** (a) combustion of fuels (at high temperature);
Accept internal combustion/aircraft/jet engines.



- (b) *Nitrogen dioxide:*
catalytic converters / control of air to fuel ratio;

Sulfur dioxide:
alkaline scrubbing / wet scrubber / limestone-based fluidized beds; [2]

- (c) $2\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_2 + \text{HNO}_3$ / $4\text{NO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \rightarrow 4\text{HNO}_3$;
 $\text{SO}_2 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_3$ / $2\text{SO}_2 + 2\text{H}_2\text{O} + \text{O}_2 \rightarrow 2\text{H}_2\text{SO}_4$; [2]

- E2.** (a) incoming solar radiation is short(er) wavelength/high(er) frequency/high(er) energy radiation / UV radiation;
(re-)radiated/emitted (by the Earth's surface) as long(er) wavelength/low(er) frequency/ low(er) energy/IR radiation;
the energy is absorbed in bonds in greenhouse gases / the molecules vibrate when IR radiation is absorbed;
the energy is (re-)radiated/(re-)emitted as IR radiation; [3 max]

- (b) carbon dioxide is more abundant;
methane is more effective at absorbing IR radiation; [2]
Award [1] for statement that "CO₂ is more abundant and CH₄ is more effective" with no mention of "at absorbing IR radiation".
Accept converse arguments.

E3. *Advantages distillation: [1 max]*

efficient as it is a multi-stage process;
 can produce water on a large scale;
 produces higher quality/purer water / produces water with less contaminants / removes more impurities;

Disadvantages distillation: [1 max]

high energy cost;
 environmental concerns due to production of large amounts of CO₂;
 corrosion of distillation equipment (by sea water and high temperature);

Advantages reverse osmosis: [1 max]

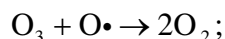
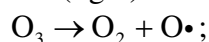
(no phase change so) requires less energy/energy consumption is lower;
 cheaper / faster to build;
 simpler to operate;

Disadvantages reverse osmosis: [1 max]

must be kept running to preserve membrane/cannot be switched off;
 membranes require careful maintenance to prevent fouling from pollutants;
 pre-treatment of sea water is required (to remove biological organisms, suspended particles and other debris);

[4]

E4. (a) UV (light)/hν/hf;



Allow O instead of O•.

[3]

(b) chlorofluorocarbons/CFCs/freons **and** spray cans/aerosol propellants/refrigerants/
 air conditioners/fire extinguishers/solvents;
 nitrogen oxides/NO_x/NO₂/NO **and** combustion of fuels (at high temperature) /
 aircraft/jet engines;

[2]

Need pollutant and its source for mark.

[1 max] if two correct pollutants given without source/without correct source.

Apply general list principle here (if two sources are given and one is correct but the other incorrect no mark awarded).

Option F — Food chemistry

F1. (a) CH_2O ;

Accept $(\text{CH}_2\text{O})_n$

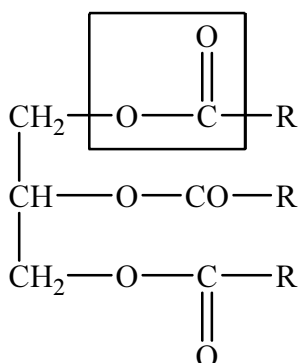
one carbonyl/ $\text{C}=\text{O}$ **and** (at least two) hydroxyl/ OH groups;

[2]

(b) (i) $\text{H}_2\text{NCH}_2\text{COOH}$;

[1]

(ii)



[2]

Award [1] for structure that shows unambiguously how the atoms are arranged together.

Award [1] for identifying one of the three ester linkages – must not include R and/or CH_2 .

(c) (i) $\text{C}_{19}\text{H}_{39}\text{COOH}$: 0

$\text{C}_{19}\text{H}_{31}\text{COOH}$: 4

$\text{C}_{19}\text{H}_{29}\text{COOH}$: 5

[2]

All three [2], any two [1], any one [0].

(ii) $\text{C}_{19}\text{H}_{29}\text{COOH}$;

greatest/most number of $\text{C}=\text{C}$ bonds / most unsaturated;

[2]

Accept: can react most easily with O_2/H_2 / light / enzymes / heat / water/hydrolysed.

F2. (a) unpleasant/disagreeable smell/taste/texture/appearance; [1]

(b) (i) *Hydrolytic process:*
lipid converted into glycerol and fatty acid (by hydrolysis of water in presence of enzymes and no C=C present);

Oxidative process:
oxidation of unsaturated fatty acid (chains)/addition of oxygen across C=C/carbon-carbon double bond; [2]

(ii) *Hydrolytic rancidity example:*
(rancid) milk / (oily or fatty acid flavour) chocolates / (soapy flavour of) cocoa butter / (rancid) butter / (foods containing) animal fat;

Oxidative rancidity example:
(oily) fish/specific example *e.g.* herring/mackerel / (any foods containing) vegetable oil; [2]

F3. *Chemical composition of foods that undergo caramelization process:*

high carbohydrate content/sucrose/reducing sugars;
without nitrogen/N-containing compounds;

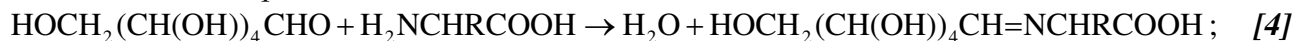
Chemical composition of foods that undergo non-enzymatic browning process:

foods containing N/amino group (of amino acid) **and** reducing sugar/glucose;

Accept chemical formulas.

Penalize omitting the word "reducing" sugar once only.

Maillard reaction equation:



F4. *Benefit:*

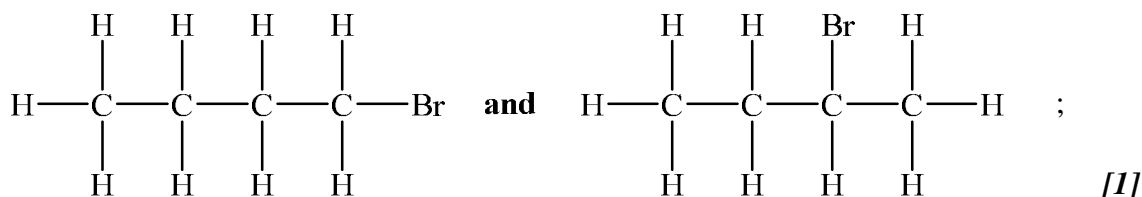
enhanced taste/flavour/quality/nutrients/vitamin A / longer shelf life / greater yield / greater resistance to pesticides/diseases;

Concern:

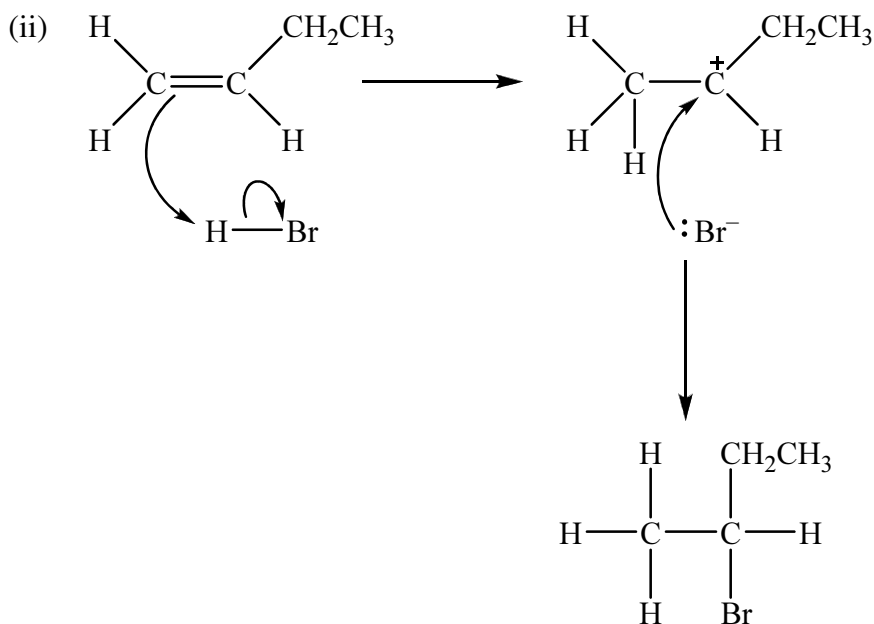
increased allergies / changed composition of balanced diet / unknown health consequences in food chain / risk of escape to wild population / lack of knowledge of potential consequences to ecosystem; [2]

Option G — Further organic chemistry

G1. (a) (i)



Accept condensed structural formulas $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br}$ and $\text{CH}_3\text{CH}_2\text{CHBrCH}_3$.



curly arrow from $\text{C}=\text{C}$ bond to H of $\text{H}-\text{Br}$ **and** curly arrow showing bond electrons going to Br ;

representation of carbocation;

curly arrow from lone pair/negative charge on Br^- going to C^+ ;

formation of $\text{CH}_3\text{CHBrCH}_2\text{CH}_3$;

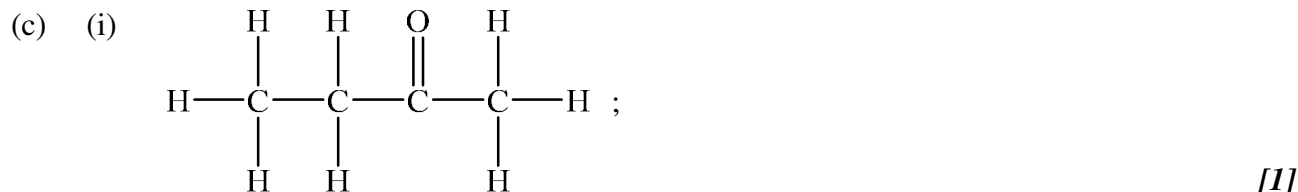
Award M1 and M2 if mechanism for the minor product given. [4]

(iii) secondary/intermediate carbocation is more stable (than primary/intermediate carbocation);

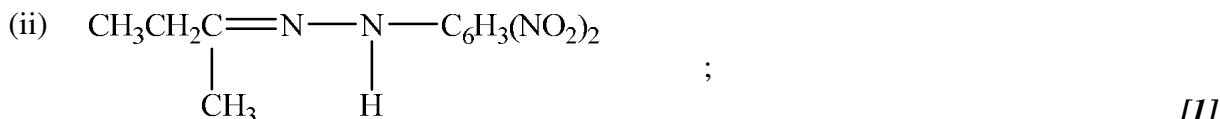
carbocation is stabilized by two electron releasing groups/positive inductive effects (compared to primary carbocation); [2]

No mark for stating due to Markovnikov's rule.

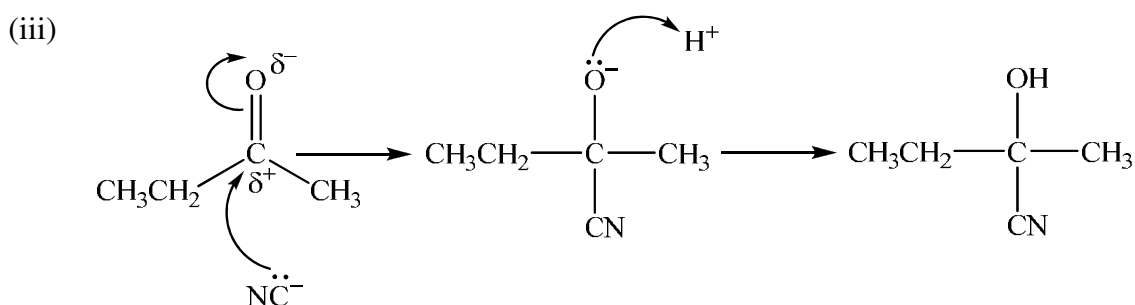
(b) (concentrated) sulfuric acid/ H_2SO_4 / phosphoric acid/ H_3PO_4 ; [1]



Accept condensed structural formula $\text{CH}_3\text{CH}_2\text{COCH}_3$.



Apply ECF if the wrong carbonyl compound is identified in (c) (i).



curly arrow from lone pair of electrons on carbon atom of CN^- to $\text{C}^{\delta+}$ on $\text{C}=\text{O}$ bond **and** curly arrow from $\text{C}=\text{O}$ bond to $\text{O}^{\delta-}$ of the $\text{C}=\text{O}$ bond;

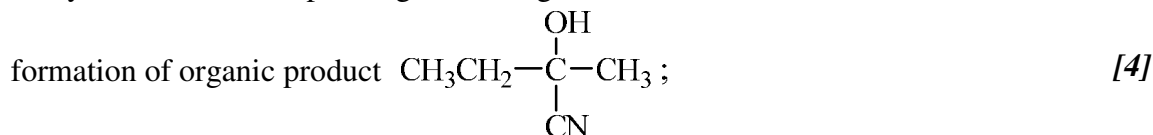
Do not allow curly arrow originating on N of CN^- .

$\delta+$ and $\delta-$ not required for marks.

representation of intermediate anion with negative charge on O;

Lone pair on O not required.

curly arrow from lone pair/negative charge on O of intermediate anion to H^+ ;



Apply ECF if the wrong carbonyl compound is identified in (c) (i).

G2. dimethylamine > methylamine > ammonia;

methyl group has positive inductive effect / is an electron releasing group / increases the electron density of the non-bonding/lone electron pair on nitrogen;

two methyl groups in dimethylamine have greater effect than one methyl group in methylamine;

[3]

- G3.** contains symmetrical/planar six membered ring/hexagonal ring;
Accept suitable diagram.

all C—C bond lengths are equal/0.139 nm / all C—C bond lengths are intermediate between single (0.154 nm) and double (0.134 nm) bonds;

all bond angles are 120° /the same;

all carbon atoms are sp^2 hybridized;

delocalization of electrons / p orbital/ π bond electrons extend over all carbon atoms;

[3 max]

Accept suitable diagrams showing resonance for the last marking point.
