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MARKSCHEME

November 2014

CHEMISTRY

Standard Level

Paper 3

24 pages

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.

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 <u>underlined</u> 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.

12. 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.

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

Option A — Modern analytical chemistry

Penalize missing hydrogens or incorrect bond linkages (eg, CO–H_2C) once only in this option.

1. (a) (i) molar/molecular mass/$M = 74$ (g mol^{-1}) / relative molecular mass/$M_r = 74$;
peak with highest *m/z* (ignoring any peak attributable to ^{13}C) /
found from parent/molecular ion peak;
Allow mass for m/z.

OR

compound has methyl/CH_3;
m/z = 15 due to CH_3^+;

OR

compound has propyl/C_3H_7/isopropyl/$CH(CH_3)_2$/acetyl/CH_3CO;
m/z = 43 due to $C_3H_7^+$/$CH(CH_3)_2^+$/CH_3CO^+;

OR

compound has acetoxy/CH_3COO;
m/z = 59 due to CH_3COO^+; ***[2]***

Fragment must contain + sign in relevant marks above.
Penalize missing charges where relevant once only in (a)(i) and (ii).

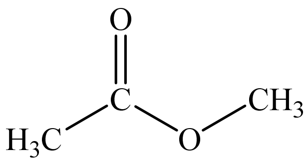
(ii) loss of $CH_3{-}O$ / loss of radical with *m/z* = 31 / formation of $C_2H_3O^+$/$C_3H_7^+$/$CH(CH_3)_2^+$; ***[1]***
Penalize missing charges where relevant once only in (a)(i) and (ii).

(b) (i) *Present:* carbonyl/C=O;
Do not accept aldehyde / ketone.
Accept ester/alkanoate only if m/z = 59 given in (a)(i).

Absent: <u>carbon-carbon</u> double bond/C=C/alkene; ***[2]***

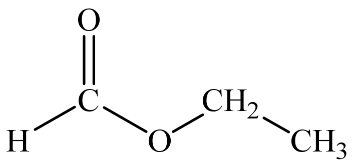
(ii) no (broad) absorption at 2500-3300 (cm^{-1});
no O–H bond; ***[2]***
*Award **[1 max]** for just stating "absorption at 1050-1410 (cm^{-1}) / C-O bond present of alcohol/ester/ether".*
Do not accept just "C-O bond present".
Accept "peak" for "absorption".

(iii) *Any two structures from:*

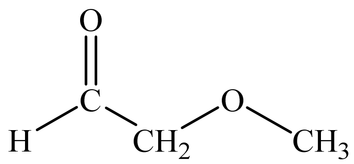


/ CH_3COOCH_3 ;

Do not penalize CH_3-C connectivity here.



/ $HCOOCH_2CH_3$;



/ $HCOCH_2OCH_3$; ***[2 max]***

(c) (i) radio (wave); ***[1]***

(ii) *I:* one signal/H environment **and** *(compound) II:* three signals/H environments;

EITHER

*Award **[1 max]** for any two of the following chemical shift ranges from the Data Booklet:*

I: 2.2-2.7 (ppm) / *II:* 2.2-2.7 (ppm)

II: 0.9-1.0 (ppm)

II: 9.4-10.0 (ppm);

Ranges must be associated with the correct compound (I or II).

OR

II: signal at 0.9-1.0 (ppm) ***and*** *I: no such signal;*

OR

II: signal at 9.4-10.0 (ppm) ***and*** *I: no such signal;* ***[2]***

Accept answers that correctly discuss differences in splitting patterns (though not on SL syllabus).

Accept "peak" for "signal".

Do not award M2 if any contradictory chemical shift ranges are given (eg, do not allow 0.9-1.0 (ppm) for compound I).

2. (a) atomic absorption / AA; ***[1]***

(b) calibrate using known standards / construct a standard calibration curve;
measure absorption from (water) sample; ***[2]***
Accept answers that correctly describe the technique, such as "involves light specific to the wavelength absorbed by copper ions" and "measures amount of light absorbed by sample" etc.

3. (a) whether chromatogram had just one spot or number of spots / *OWTTE*; ***[1]***
Allow "component/dot / OWTTE" for spot.

(b) different components have different attractions/affinities/bond strengths/solubilities for two phases / *OWTTE*;

components strongly absorbed/adsorbed by stationary phase move less / components weakly absorbed/adsorbed by stationary phase move more / components not very soluble in mobile phase move less / components very soluble in mobile phase move more / *OWTTE*; ***[2]***

(c) distance travelled by component divided by distance travelled by solvent (front); ***[1]***
Allow spot/solute for component.
Accept R_f represented as an equation.
Do not allow just retention factor.

(d) (nature of) solvent (used) / (type of) paper / temperature / pH; ***[1]***

Option B — Human biochemistry

Penalize missing hydrogens or incorrect bond linkages (eg, CO–HN) once only in this option.

4. (a) mass (in g) of I_2/iodine reacting with 100 g of fat/oil/substance/lipid; ***[1]***
Allow "grams of I_2" instead of "mass (in g) of I_2".
Allow amount/number of mol of I_2 reacting with 1 mol of fat/oil/substance/lipid.
Do not accept mass number for mass.

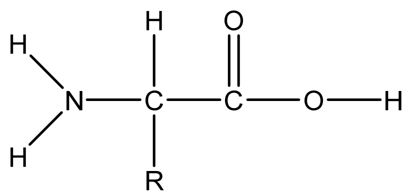
(b) $\left(\frac{3.02}{302}=\right)0.0100\,(\text{mol})$ acid;
$\left(\frac{12.7}{254}=\right)0.0500\,(\text{mol})\ I_2$;
$\left(\frac{0.0500}{0.0100}=\right)5$ (carbon-carbon double bonds); ***[3]***
*Award **[1 max]** for 5 if no working shown.*

5. *Any two of:*
diverticulosis;
irritable bowel syndrome;
Accept IBS.

constipation;
obesity;
heart attack / *OWTTE*;
Crohn's disease;
haemorrhoids;
Accept piles.

diabetes (mellitus);
colorectal/bowel cancer; ***[2 max]***
Do not allow just cancer.

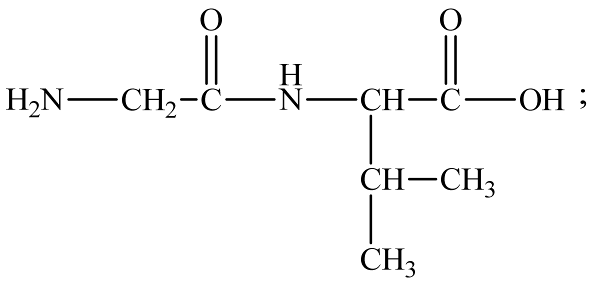
6. (a)

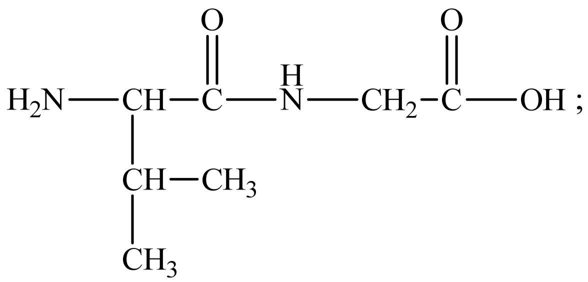


; ***[1]***

Allow condensed structural formula (eg, R-CH(NH_2)COOH) or structure of a specific 2-amino acid (eg, Ala etc.).

(b) (i)





[2]

Accept condensed structural formulas.
Accept C_3H_7 for CH_3CHCH_3.

(ii) H_2O/water; *[1]*

(c) add hydrochloric acid/HCl to separate individual amino acids;
Accept strong acid/concentrated H^+ or restriction enzymes but not sulfuric acid/H_2SO_4.

*Award **[4 max]** for any four of:*
mixture/amino acids spotted/placed on gel/PAGE/polyacrylamide/paper;
gel placed in buffer/solution of known pH;
voltage/potential difference applied;
Accept "applied electric field / positive and negative electrodes connected / anode and cathode connected" but not current.

amino acids move differently depending on size and charge/isoelectric point/pH of buffer / amino acids move to oppositely charged electrodes;
Accept any suitable diagram.

develop with ninhydrin/(organic) dye / detect by UV (light)/staining/fluorescence;
Accept any suitable development method.

measure distances moved / compare with known samples / measure isoelectric points; *[5]*

7. (a) maintain good health / prevent health problems / absence can leads to health problems; ***[1]***

Allow named health problem eg, heart disease/dermatitis/eczema/depression etc.
Allow lowering levels of LDL/low-density lipoprotein.
Allow human body cannot synthesize/produce such acids / OWTTE.

(b) *Similarities:*
*Award **[3 max]** for any three similarities of:*
both contain 18 carbons/same number of carbons;
both unsaturated/contain C=C/carbon-carbon double bonds;
Do not allow just double bond.

both contain carboxyl/COOH/CO_2H;
Allow "both carboxylic acids".

both have first (carbon to carbon) double bond/C=C on C9;
both have *cis*-configuration of (all) C=C (fragments);

Differences:
*Award **[1 max]** for any one difference of:*
linoleic acid (omega-6) contains 2 C=C **and** linolenic acid (omega-3) contains 3 C=C / linolenic acid has one more C=C;
Allow linolenic acid more unsaturated.

closest C=C on linoleic acid is on sixth carbon from methyl end **and** closest C=C on linolenic acid is on third carbon from methyl end / *OWTTE*; ***[4]***
*Accept linoleic acid is omega-6/ω-6 **and** linolenic acid is omega-3/ω-3.*
Award similarity mark M2 automatically as long as either difference mark is scored.

Option C — Chemistry in industry and technology

8. (a) *Positive electrode (anode):*
$2O^{2-} \rightarrow O_2(g) + 4e^- \ / \ O^{2-} \rightarrow \frac{1}{2}O_2(g) + 2e^- \ / \ 2O^{2-} - 4e^- \rightarrow O_2(g) \ /$
$O^{2-} - 2e^- \rightarrow \frac{1}{2}O_2(g)$;
Allow $C(s) + 2O^{2-} \rightarrow CO_2(g) + 4e^-$.

Negative electrode (cathode):
$Al^{3+} + 3e^- \rightarrow Al(l)$; ***[2]***

Accept e instead of e^-.
Ignore state symbols.
If correct equations shown at wrong electrodes, award ***[1 max]***.

(b) (i) harder/stronger (than pure aluminium); ***[1]***

(ii) *Award* ***[1]*** *for any two of*:
good conductor of electricity;
resists corrosion;
Do not allow rusting.

low density;
Do not allow lighter/light mass/light weight.

ductile; ***[1 max]***
Do not allow malleable.

9. (a) homogeneous; ***[1]***

(b)

Catalyst	Mechanism	Disadvantage
Fe^{2+} (aq)	oxidized (by the OA) and subsequently reduced (by the RA) / undergoes redox reaction / changes oxidation state/number;	difficult to separate from reaction mixture; prone to poisoning;
Fe (s)	reactants are <u>adsorbed</u> onto surface (where reaction takes place) / reaction occurs on surface / weakens reactant bonds;	only effective on surface / must be finely divided; prone to poisoning; *Allow "must be cleaned/refreshed / OWTTE".*

[4]

Allow "prone to poisoning" as a disadvantage for either but not both.

10. *Award **[1 max]** from each box – allow opposite statements:*

	One advantage	One disadvantage
Fuel cells	chemical energy directly converted to electrical; more efficient than traditionally generated electricity; non-polluting; *Accept "produces water/H_2O" but not "environmentally friendly".* no need to recharge;	hydrogen is dangerous/highly flammable/explosive; (both) gases are difficult to store/transport; expensive to set up; susceptible to leaks/corrosion; uses up fuel;
Lead-acid batteries	can deliver large amounts of electrical energy in short time / produces high current; *Do not allow "high voltage".* can be electrically recharged / stores electricity; compact and portable; (relatively) cheap;	heavy; lead/sulfuric acid are pollutants; finite amount of energy available / stops working while recharging;

[4]

Do not accept an advantage in one column as a disadvantage in another column.

11. (a) fluids that have physical properties dependent on molecular orientation/orderly molecular arrangement; ***[1]***
Allow "fluids that exhibit molecular orientation/orderly molecular arrangement".
Allow "(LCs) show properties of liquids and crystals simultaneously".

(b) thermal agitation disrupts directional order of liquid crystal / *OWTTE*;
rotation of plane polarized light disrupted / crystals no longer have ability to affect light in same way / *OWTTE*; ***[2]***

12. (a) (research/technology development at) 1–100 nm (range);

*Award **[1 max]** for any one of:*
creates/uses structures with novel properties (because of their small size) / *OWTTE*;
builds on ability to control/manipulate at atomic scale / *OWTTE*; ***[2]***

(b) explosive / small size/large surface area means very fast reactions at possibly dangerous levels;
unknown health effects / immune system/allergy concerns;
industry not concerned about impact of product;
lack of public awareness about dangers;
nanoparticle waste products may require new methods of disposal;
nanoweapons more difficult to detect than conventional weapons (resulting in weapons of mass destruction);
possible toxicity (of small airborne particles); ***[2 max]***
Do not allow just "may cause environmental destruction".
Accept other valid concerns.
Accept OWTTE throughout.

Option D — Medicines and drugs

13. (a) *Mild analgesics:*
mild analgesics work by intercepting pain stimulus at source;
suppress production of prostaglandins/pain sensitizing substances / *OWTTE*;

Strong analgesics:
strong analgesics work directly on opioid/pain receptors in brain;
suppress transmission of pain impulses in brain/CNS / *OWTTE*; ***[4]***

(b) ester; ***[1]***
Accept alkanoate/ethanoate/acetoxy.

(c) *Advantages:*
*Award **[1 max]** for any two of:*
strong pain relief / strong analgesic;
sedation / *OWTTE*;
treatment of diarrhoea;
relieve coughing;

Disadvantages:
*Award **[1 max]** for any two of:*
addiction;
tolerance;
dependence;
constipation; ***[2]***
depresses respiratory drive;
Accept "criminals/drug addicts might get access to strong analgesics intended for medical use" / OWTTE.

*Award **[1 max]** if one advantage **and** one disadvantage are given.*

14. *One similarity:*
*Award **[1 max]** for any one of:*
both contain halogens;
both contain phenyl (groups);
Allow benzene/aromatic ring or aromatic/aryl groups/fragments for phenyl but not benzene or arene alone.
Do not allow "both have chloro groups" as a similarity.

One difference:
*Award **[1 max]** for any one of:*
fluoxetine hydrochloride has a (substituted) ammonium (diazepam does not);
diazepam contains an amido (group) (fluoxetine hydrochloride does not);
Allow amide for amido.

fluoxetine hydrochloride is ionic (diazepam is not);
Allow salt instead of ionic.

diazepam has a chloro (group) / fluoxetine hydrochloride has a chloride (ion/anion);
fluoxetine hydrochloride has an ether (group) (diazepam does not);
diazepam contains an imino (group) (fluoxetine hydrochloride does not);
Allow imine/ketimine for imino.

fluoxetine hydrochloride contains a trifluoromethylphenyl (group) (diazepam does not); ***[2]***
Allow trifluoromethyl for trifluoromethylphenyl (group).
Accept any other correct comparison.

15. (a) (tertiary) amino; ***[1]***
Allow amine.

(b) *Award **[1]** for any two of:*
anxiety/restlessness;
irritability;
sleeplessness/insomnia;
increase in urine output/diuretic;
dehydration;
nausea;
headaches;
increase heart rate/tachycardia / increase blood pressure/tension;
increase metabolic rate;
trembling/shaking; ***[1 max]***
Do not accept stimulant.
Do not accept decrease in appetite.

16. (a) isolated/purified/concentrated penicillin;
Accept extract penicillin.

first successful animal (mice) test / harmless to mice;
first person tested responded favourably / *OWTTE*; ***[2 max]***
Do not allow just "tested on humans" but accept "tested successfully on humans / OWTTE".
Do not allow large-scale production (since attributed to Moyer and Rousseau, not Florey and Chain);

(b) penicillins interfere with (enzymes involved with) development of cell wall/(cross-link) structure of bacteria;
(due to damage) cells absorb water (by osmosis) **and** burst / *OWTTE*;
modifying side-chain overcomes resistance (by bacteria) / *OWTTE*; ***[3]***

17. (a) bacteria are a single cell / viruses are not cellular;
bacteria have cell walls/nuclei / viruses have no nucleus/cell wall;
bacteria larger than viruses / viruses smaller than bacteria;
viruses need host cell to reproduce / viruses take over another cell;
bacteria are organisms/living / bacteria metabolise/can grow/feed/excrete / viruses are not living / viruses do not metabolise/grow/feed/excrete; ***[2 max]***
Allow " bacteria have both DNA and RNA / viruses have either RNA or DNA only (but not both)".

(b) alter cell's genetic material;
block enzyme activity within host cell;
(changes cell membrane so that it) inhibits virus entry/bonding to cell;
prevents virus from leaving cell (after reproduction);
becomes part of DNA of virus / alters virus / blocks enzyme (polymerase) which builds DNA;
prevents virus from using cell to multiply/reproduce/replicate / prevents virus from using cell's metabolism; ***[2 max]***

Option E — Environmental chemistry

18. (a) *Natural:* electrical storms/lightning / bacterial decomposition;
Anthropogenic: high temperature combustion in cars/planes/industrial furnaces; ***[2]***

(b) acid deposition / acid rain / nitrous acid / nitric acid;
(photochemical) smog / PANs/peroxyacyl nitrates / ozone; ***[1 max]***
Accept chemical formulas.

(c) catalytic converters / control of fuel-to-air ratio / lean burn engine / use of alternative energy sources / reduce energy consumption / reduce use of gas/petrol engines; ***[1]***
Allow "recirculation of exhaust gases/EGR (lowering operating temperature)".

19. (a) incoming solar radiation is short wavelength/high frequency/higher energy/UV;
(re-)radiated/emitted (by Earth's surface) as long wavelength/low frequency/low energy/IR radiation;
energy absorbed by (bonds in) greenhouse gases / molecules vibrate when IR radiation absorbed;
energy (re-)radiated/(re-)emitted as IR radiation some of which returns back to Earth; ***[3 max]***
Do not accept reflected, bounced or trapped.

(b) CH_4 / methane;
decomposition of organic matter / livestock/ruminant/cows/sheep / manure / swamps/marshes / rice paddies / oil/gas field / anaerobic microbial activity in lakes/ponds / composting;

OR

N_2O / nitrogen(I) oxide/dinitrogen monoxide/nitrous oxide;
bacterial decomposition/action / combustion/burning of biomass / artificial/nitrogeneous/synthetic fertilizers;

OR

CFCs / chlorofluorocarbons;
solvents / production of polymers / refrigerants / foaming agents / propellants/aerosols / air conditioning units;

OR

SF_6 / sulfur hexafluoride;
electronics industry / high voltage/electrical switches / circuit breakers / electrical generators / insulator used in electrical industrial applications/gas-insulated substations / production of magnesium / *OWTTE*; ***[2]***

Accept any other correct answers such as "nitrogen trifluoride/NF_3 used in electronics industry / manufacture of semi-conductors/computer chips/circuits / (thin-film) solar/photovoltaic cells / solar panels / LCD televisions / chemical lasers" OR "trifluoromethyl sulfur pentafluoride/SF_5CF_3 formed (as by-product from SF_6) in high-voltage equipment / by-product of fluorochemical manufacture".
M2 can only be scored if M1 correct.

20. (a) *Formation:*

$O_2(g) \xrightarrow{\text{UV (light)}/h\nu/hf} 2O\bullet(g)$;

$O_2(g) + O\bullet(g) \rightarrow O_3(g)$;

Depletion:

$O_3(g) \xrightarrow{\text{UV (light)}/h\nu/hf} O_2(g) + O\bullet(g)$;

$O_3(g) + O\bullet(g) \rightarrow 2O_2(g)$; ***[3 max]***

Allow representation of radical without • if consistent throughout mechanism.
UV(light)/hν/hf can be represented above arrow or mentioned in accompanying description in words.
Penalize omission of UV (light)/hν/hf once only.
Ignore state symbols.

(b) (both alternatives) do not produce chlorine atoms/radicals in UV (light);
(both alternatives) less stable in atmosphere/have shorter atmospheric lifetimes/have lower potential for global warming/GWP (than CFCs) / *OWTTE*;
hydrocarbons can be disposed of by combustion;
hydrocarbons do not have to be synthesised/are cheap;
C-H bond enthalpy/strength (413 kJ mol^{-1}) greater than C-Cl bond enthalpy/strength (346 kJ mol^{-1}); ***[2 max]***
Do not allow just "low reactivity" or "low toxicity (compared to CFCs)".

21. (a) *One advantage of landfill:*
good for dealing with large volumes of waste / land when filled can be used for building purposes / no separation of rubbish/garbage required / cheap / can be expanded easily (where land is available) / *OWTTE*;
Do not accept "no air pollution".

One disadvantage of landfill:
poisonous/toxic chemicals can be produced / heavy metal (ions) leaching into drinking water supplies/source of underground pollution (soil or water) / often odours occur in immediate environment / non-biodegradable plastics/polymers may not be broken down / unsightly / takes up land (where land is expensive/unavailable) / occupies large area / produces methane/CH_4/greenhouse gas / *OWTTE*;

One advantage of incineration:
reduces volume of waste (only ash remains) / odour-free (stable) compounds produced / energy source (so can reduce energy cost) / produces slag/ash residues which can be used in building / *OWTTE*;
Do not accept "no land pollution".
Accept "uses less land".

One disadvantage of incineration:
high construction costs / can form dioxins/toxic/poisonous gases/vapours/ CO/carbon monoxide / needs energy (to run plant) / adds to greenhouse effect (due to carbon dioxide/CO_2 generated) / chlorinated compounds/polymers/plastics can generate hydrochloric acid/HCl resulting in acid rain; ***[4]***

Do not accept advantage of one being disadvantage of the other.

Do not accept general statements without support.

(b) may leak into water (table);
remains active for a very long time / long half-life/$t_{1/2}$;
geological instability (*eg,* earthquakes) / *OWTTE*;
potential weapon for terrorists / *OWTTE*; ***[2 max]***

Option F — Food chemistry

22. (a)

Nutrient		Food source
carbohydrates	**and**	bread / cereals / grains / pasta / fruit / vegetables / (table) sugar;
proteins	**and**	meat / fish / eggs / dairy products / nuts / seeds / grains / beans / mushrooms / tofu/soy;
vitamins	**and**	fruit / vegetables / meat / fish / eggs / dairy products;

[2 max]

*Award **[1 max]** for two correct nutrients.*
Accept vegetables for proteins.
Do not accept "fortified food/vitamin supplements" as a food source for vitamins.
Accept other valid food sources for each nutrient.

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

(ii) water/H_2O; ***[1]***

(c) (i) (fatty acids in) oils are unsaturated/contain (many) <u>C=C/carbon-carbon double</u> bonds / (fatty acids in) fats are (mostly) saturated/contain no/few/fewer (than oils) <u>C=C</u> /<u>carbon-carbon double</u> bonds; ***[1]***

(ii) C=C bonds degrade/oxidize more rapidly / oils become rancid more rapidly / fats are more stable;

*Award **[1 max]** for any two of:*
auto-oxidation;
Allow oxidative rancidity.
Do not accept "reaction with oxygen" (name required).

photo-oxidation;
Do not accept light.

microbial rancidity;
hydrolysis; ***[2]***
Allow hydrolytic rancidity.
Do not accept "addition of water" (name required).
Do not accept hydrogenation (since not a degradation reaction).

23. (a) (i) length of time before food is considered unsuitable for sale/use/consumption / length of time that food maintains its expected quality;
owing to changes in taste/flavour/smell/odour/texture/appearance/colour; ***[2]***
Do not give credit for answers of the type "the food is no longer safe to eat".

(ii) water content;
loss of nutrients / browning / rancidity / microbial spoilage / loss of texture;

OR

pH change;
Do not allow chemical change.

off flavours / colour changes / browning / loss of nutrients;

OR

light;
rancidity / vitamin loss / fading of natural colours;

OR

temperature;
changes rate of other types of spoilage;

OR

contact with air/oxygen;
increases rate of reactions involving oxygen / browning; ***[2]***

M2 can only be scored if M1 correct.

(b) *Award* ***[1 max]*** *for any two of:*
fermentation;
Allow "addition of sugar".

cooling / keeping it in ice;
pickling;
salting;
drying;
smoking; ***[1]***
Do not allow preserving.

24. (a) (i) heme initially present as oxymyoglobin/MbO_2/myoglobin/Mb;
in both iron is Fe^{2+};
auto-oxidation causes $Fe^{2+} \rightarrow Fe^{3+}$ / formation of MMb/metmoyglobin;
Fe^{3+} causes discolouration / Fe^{3+} causes brown-red colour; ***[3 max]***

(ii) store free of oxygen/air / vacuum pack;
pack in carbon dioxide/CO_2/nitrogen/N_2/inert gas;
freezing / refrigeration;
Allow "keep in a cold place".

place in low gas permeability packaging/film/plastic/polymer; ***[1 max]***

(b) minimise health risks caused by food/people crossing borders;
stimulate international trade / *OWTTE*; ***[2]***

25. possible links to allergies;
risk of passing antibiotic-resistant genes to harmful organisms;
risk of changing natural nutritional quality of foods / potential risk to health of changing diet;
Do not allow just "harmful to health".

as yet unknown effect on food chain;
unknown consequences of mixing GM DNA with unmodified DNA / uncertain effects of GM organisms breeding with unmodified organisms;
reduce biodiversity / loss of variety of species;
susceptibility to "superbugs" / *OWTTE*;
control of food production by corporations (since GM organisms are protected by patents/licences) / *OWTTE*; ***[2 max]***

Option G — Further organic chemistry

Penalize missing hydrogens or incorrect bond linkages (eg, C–H$_3$C) once only in this option.

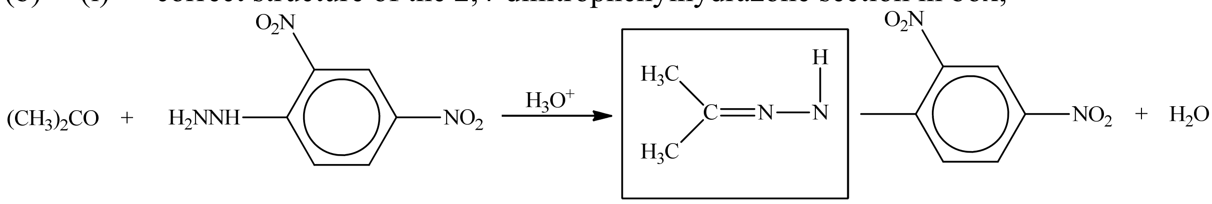
26. (a) (i) alcohols < phenols < carboxylic acids; ***[1]***
Accept correct order involving named compounds ie,
(propanol < phenol < propanoic acid).

(ii) halogens make them more acidic;
halogens are electron withdrawing;
Accept halogens (can be) electronegative.
reduces charge on/stabilizes anion formed / weakens O–H bond / makes it easier to lose H^+ ion; ***[3]***
Accept decreases pK_a.
Accept causes anion to be weaker base.

(iii) steric hindrance/repulsion from delocalized electrons / *OWTTE*;
lowers partial charge on carbon attached to chlorine atom / *OWTTE*;
partial double bonding between chlorine and ring (through incorporation of lone pair into delocalized electrons) / interaction between lone pairs on chlorine and delocalized electrons strengthens C–Cl bond / *OWTTE*; ***[2 max]***

(iv) *Equation:* $C_6H_5Cl + Mg \rightarrow C_6H_5MgCl$;
Condition: dry / absence of water; ***[2]***
Accept ether (solvent).

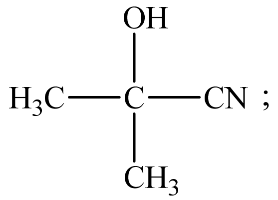
(b) (i) correct structure of the 2,4-dinitrophenylhydrazone section in box;



[1]

(ii) yellow/orange <u>solid/precipitate</u>; ***[1]***

(c) (i) *Structure of **A**:*

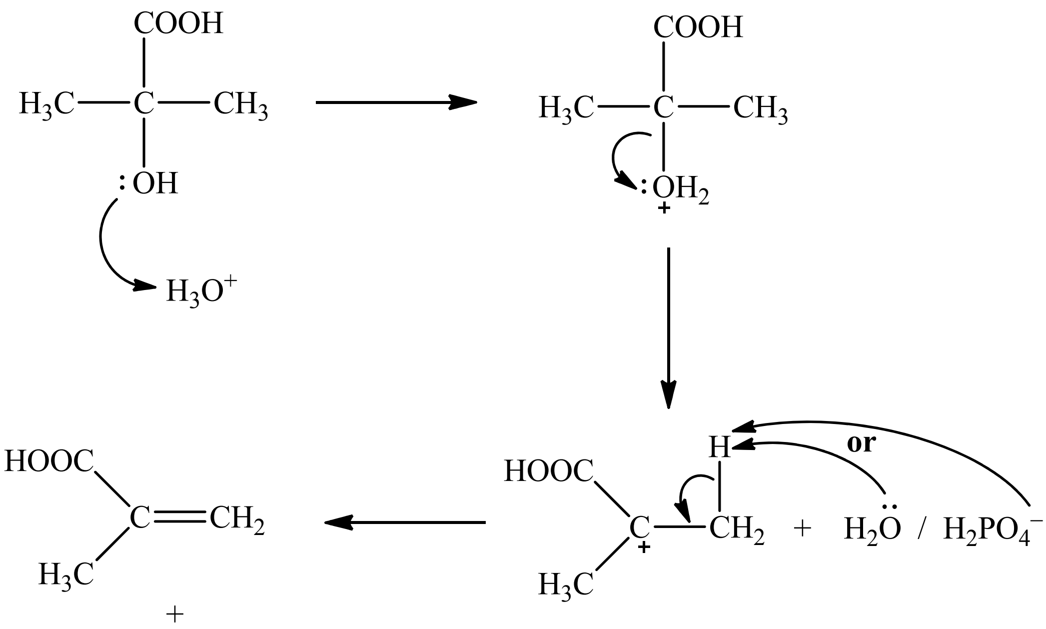


M2 and M3 can only be scored if M1 correct.

*Reagent to form **A**:*
cyanide ion/CN^- / hydrogen cyanide/HCN / sodium cyanide/NaCN / potassium cyanide/KCN;
Accept other ionic cyanides.

*Reagent for converting **A** to the final product:*
dilute acid / $H^+(aq)/H_3O^+(aq)$; ***[3]***
Allow identified acid (eg, HCl(aq)).
Answer must refer to aqueous/dilute/H_2O for mark.

(ii)



H_3O^+/H_3PO_4

curly arrow going from lone pair on O to H^+/H_3O^+;
representation of positively charged O intermediate **and** curly arrow showing H_2O leaving;
curly arrow going from lone pair on O of $H_2O/H_2PO_4^-$/negative charge on O of $H_2PO_4^-$ to H **and** curly arrow going from CH bond to C–C^+ to form C=C;
No mark awarded if C^+ is not identified.
formation of organic product $(HOOC)(CH_3)C{=}CH_2$ **and** H_3O^+/H_3PO_4; ***[4]***

(d) one product involves a primary carbocation **and** other a secondary carbocation;
secondary carbocation is more stable (than the primary carbocation, and hence this produces the major product);
alkyl groups reduce charge on carbon atom (through an inductive effect); ***[3]***
Positive inductive effect of alkyl groups alone not enough for M3.