N11/4/CHEMI/HP3/ENG/TZ0/XX/M

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MARKSCHEME

November 2011

CHEMISTRY

Higher Level

Paper 3

23 pages

Subject Details: Chemistry HL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options **[2 x 25 marks]**.
Maximum total = **[50 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 mark scheme, similarly, if the formula is specifically asked for, unless directed otherwise in the mark scheme 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.

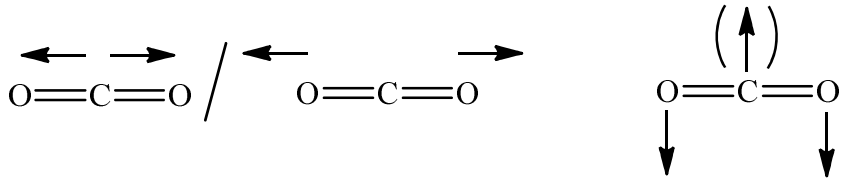
Option A — Modern analytical chemistry

A1. (a) *UV*:
electronic transitions;

Microwave:
molecular rotation; ***[2]***

(b) *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.

A2. (a)



(symmetric) stretching (symmetric) bending ***[2]***

*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 $(COOH)^+$ / $(M_r - 15)^+$ due to loss of CH_3;

$HCOOCH_3$:
peak at 31 due to $(OCH_3)^+$ / $(M_r - 29)^+$ due to loss of HCO/CHO / peak at 29 due to $(HCO)^+$/$(CHO)^+$ / $(M_r - 31)^+$ 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]***

A4. (a) phenolphthalein in acid solution has less conjugation/delocalization / in alkaline solution has greater conjugation/delocalization / *OWTTE*;

greater conjugation/delocalization (of electrons), less energy required to excite electrons / high(er) wavelength/low(er) frequency/absorbs in the visible range (not UV), so appears coloured; ***[2]***
Accept converse argument.

(b) 230–400 (nm);
Accept any value or any range within 230–400 (nm).

greater conjugation/delocalization in oxybenzone compared to phenolphthalein structure in acidic solution / less(er) conjugation/delocalization of phenolphthalein structure in alkaline solution / *OWTTE*; ***[2]***

A5. (a) GLC involves vaporizing a sample at high temperature;
alcohols can (easily) vaporize without decomposing / sugar molecules are temperature sensitive/decompose at high temperature/non-volatile; ***[2]***

(b) (non-polar or polar) mobile/liquid phase **and** (short, polar or non-polar) solid/stationary phase;
Accept suitable names for mobile and stationary phases.

mobile phase forced (through the column) under pressure (at constant temperature);
sample placed in liquid stream / components separate as they pass through tube;
detected by absorption of UV/fluoresence/conductivity;
*Award **[1]** each for any three of first four marking points.*

components reach detector at different times/R_t / compare retention times to standard samples (under identical conditions); ***[4 max]***

Option B — Human biochemistry

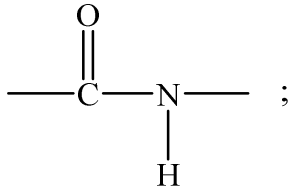
B1. $q = [m \times c \times \Delta T]_{\text{water}} + [C \times \Delta T]_{\text{glass}} = [100.00 \times 4.18 \times 9.4] + [90.2 \times 9.4]\,(\text{J})$;
$= [3929.2 + 847.88] / 4777.08\,(\text{J})$;
energy value $= \dfrac{[4777.08 \times 100]}{5.00} = 95541.6\,(\text{J}) = 95.5\,(\text{kJ})$; ***[3]***

Apply ECF as follows:

M1 *Likely errors are to omit the $C\Delta T$ 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:*

M2	*(omitting $C\Delta T$)*	*(using 5.00 g)*	*(omitting $C\Delta T$ and using 5.00 g)*
	3929.2 (J)	*1044.34 (J)*	*196.46 (J)*
M3	$\dfrac{3929.2 \times 100}{5.00} = 78.6\,(kJ)$	$\dfrac{1044.34 \times 100}{5.00} = 20.9\,(kJ)$	$\dfrac{196.46 \times 100}{5.00} = 3.93\,(kJ)$

B2. (a) peptide/amide;



; ***[2]***

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) alcohol; ***[1]***
Accept hydroxyl.

B4. 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]***

B5. (a) enzymes have an active site (where the substrate can bind) / explanation of lock and key or induced fit model;
lowers activation energy (by providing an alternative pathway); ***[2]***

(b) increasing temperature initially increases rate of reaction;
because more molecules possess energies equal or greater than the activation energy;
at a temperature around 37 °C , the highest rate is reached;
at a temperature around 40 °C the enzyme is denatured / shape of the active site changes/tertiary structure of the enzyme changes;
so rate decreases/reaction stops; ***[4 max]***

B6. (a) phosphate group **and** pentose/deoxyribose (sugar) **and** organic/nitrogenous base; ***[1]***
Accept suitable diagram.
No mark for just sugar or just base.

(b) condensation reaction / covalent bond between phosphate on one nucleotide and pentose sugar on next; ***[1]***
Accept suitable diagram.
Penalize just sugar only once.

(c) DNA is separated from blood sample / *OWTTE*;
DNA is broken down/cut into mini-satellites/fragments by <u>restriction</u> enzymes;
mini-satellites/fragments separated by gel electrophoresis;
*Do **not** accept chromatography.*

pattern detected by labelling with ^{32}P/radioactive P and using X-ray film/staining with fluorescent dye; ***[3 max]***

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/cools (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) all atoms in the two monomers end up in the polymer / it is an addition reaction;
condensation should involve loss of a (small) molecule / no loss of small molecule in the reaction / *OWTTE*; ***[2]***
Accept water in place of (small) molecule.

(c) chains have trans orientation / close approach between straight chains / chains have polar (N–H and C=O) groups / amide linkages (which are aligned) / *OWTTE*;
H-bonding between chains (give it great strength); ***[2]***

(d) 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)*:
$O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$;

Negative electrode (anode):
$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^-$; ***[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;
(on average) molecules point in same direction/orientation/directional order; ***[2]***
Accept suitable diagram.

(b) directional order decreases/is lost / starts to behave like a liquid;
extra energy causes greater movement/overcomes intermolecular forces; ***[2]***

C5. (a) (i) (organic) fluoropolymer / ion-exchange/semi-permeable membrane; ***[1]***

(ii) *Positive electrode (anode)*:
$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ / $Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$;

Negative electrode (cathode):
$2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$ / $H_2O(l) + e^- \rightarrow OH^-(aq) + \frac{1}{2}H_2(g)$; ***[2]***
Ignore state symbols.
Allow e instead of e^-.
*Allow **[1]** if correct equations but incorrect electrodes.*

(b) does not use asbestos as it scars tissue / causes asbestosis;
does not use Hg is toxic/poisonous/causes kidney failure/blindness/damage to brain/CNS/ minamata disease;
membrane cell uses inert material / is cheaper/economical / more energy efficient / produces higher quality NaOH/of higher concentration; ***[2 max]***
Needs reference to dangers to score M1 and M2.

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) *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]***

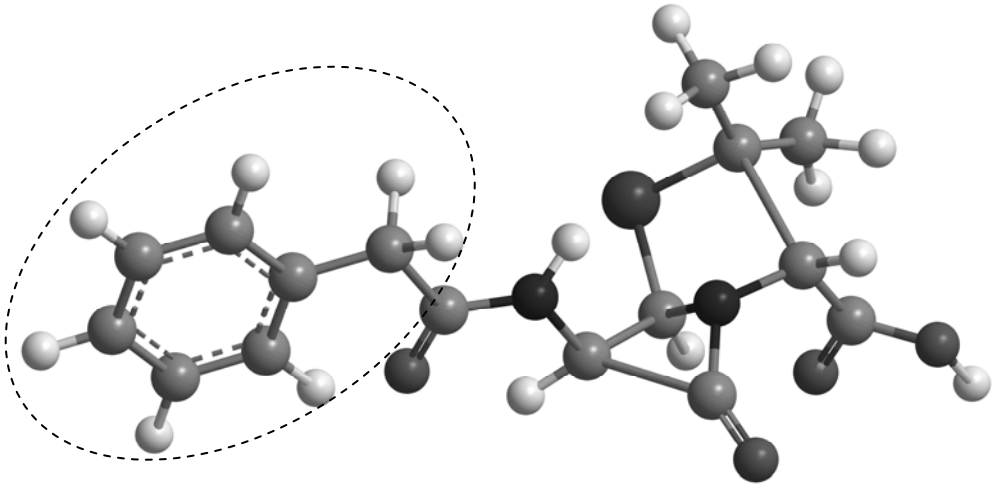
(b) epinephrine/adrenaline;
forms hydrogen bonding (with water); ***[2]***
No mark if amphetamine is given as the answer.

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

(ii) basic;
(lone e^- pair on) N(s) can accept H^+/proton acceptor / hydrolyses to form $OH^-(aq)$; ***[2]***
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]***

D3. (a)



;

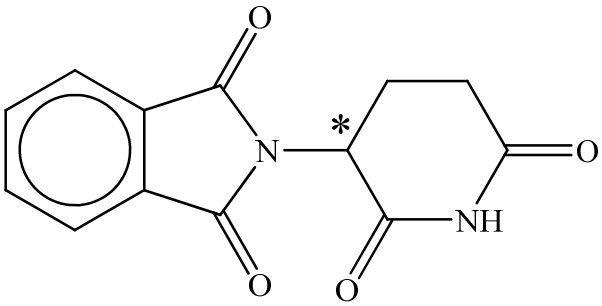
[1]

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]***

D4. (a)



;

[1]

(b) <u>equimolar/50:50</u> mixture (of a pair) of enantiomers/both isomers; ***[1]***

(c) one enantiomer alleviates morning sickness (in pregnant women) / causes desired effect;
other causes (limb) deformities (in fetuses) / harmful effects;
important to test both enantiomers separately / use only desired one in a drug; ***[2 max]***

D5. (a) (i) $CH_3COO(C_6H_4)COOH + NaOH \rightarrow CH_3COO(C_6H_4)COONa + H_2O$; ***[1]***

Accept Na_2CO_3 or $NaHCO_3$.
Accept ions for strong base and salt or net ionic equation.

(ii) $F_3C(C_6H_4)OCH(C_6H_5)CH_2CH_2NHCH_3 + HCl \rightarrow$
$F_3C(C_6H_4)OCH(C_6H_5)CH_2CH_2N^+H_2(CH_3)Cl^-$; ***[1]***

Accept ... $\overset{+}{N}H_2(CH_3)Cl^-$
Charges and brackets not required to score marks.

(b) chiral auxiliaries are enantiomers/optically active;
auxiliary creates stereochemical condition necessary to follow a certain pathway / is used to manufacture one enantiomer (so avoids need to separate a racemic mixture);
attaches/connects itself to non-chiral molecule / makes it optically active;
only desired/one enantiomer/molecule formed (and chiral auxiliary removed); ***[2 max]***

(c) *For* ***[1 max]***
specific effect on certain diseases *e.g.* relieves nausea in cancer patients to gain mass/weight / relieves glaucoma/Parkinson's disease symptoms / increases appetite in AIDs patients;
personal freedom argument / frees police to deal with other/more serious crimes / more taxes / *OWTTE*;
No mark for comment such as: cannabis is no more harmful than other legal drugs so why should cannabis be different.

Against ***[1 max]***
increased risk of lung cancer / respiratory ailments / may suppress body's immune system;
may lead to use of harder drugs; ***[2 max]***

Option E — Environmental chemistry

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

$N_2 + O_2 \rightarrow 2NO$ **and** $2NO + O_2 \rightarrow 2NO_2$; ***[2]***

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

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

(c) $H_2O + O_3 \rightarrow 2HO\bullet + O_2$ / $H_2O + O\bullet \rightarrow 2HO\bullet$;
$HO\bullet + NO_2 \rightarrow HNO_3$;
$HO\bullet + SO_2 \rightarrow HOSO_2\bullet$;
$HOSO_2\bullet + O_2 \rightarrow HO_2\bullet + SO_3$; ***[4]***
No penalty for missing the free radical sign.
M3: Accept $S + O_2 \rightarrow SO_2$.
M4: Accept $2SO_2 + O_2 \rightarrow 2SO_3$.

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 "CO_2 is more abundant and CH_4 is more effective" with no mention of "at absorbing IR radiation".*
Accept converse arguments.

E3. (a) $K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$;

$[Ca^{2+}] = \frac{3}{2}[PO_4^{3-}]$ **and** $1.20\times10^{-26}(\text{mol}^5\,\text{dm}^{-15}) = \left[\frac{3}{2}[PO_4^{3-}]\right]^3[PO_4^{3-}]^2$;

$[PO_4^{3-}] = 5.13\times10^{-6}(\text{mol dm}^{-3})$;

OR

$Ca_3(PO_4)_2 \rightleftharpoons 3Ca^{2+} + 2PO_4^{3-}$

$x \qquad 3x \qquad 2x \qquad K_{sp} = 1.20\times10^{-26}$

$K_{sp} = [Ca^{2+}]^3[PO_4^{3-}]^2$;

$= (3x)^3.(2x)^2$

$= 27x^3.4x^2$

$= 108x^5$

$\therefore x = \sqrt[5]{\frac{1.20\times10^{-26}}{108}}$

$= \sqrt[5]{1.1111\times10^{-28}}$

$x = 2.565\times10^{-6}$;

$\therefore [PO_4^{3-}] = 2x$

$= 2\times2.565\times10^{-6}$

$= 5.13\times10^{-6}\,\text{mol dm}^{-3}$; ***[3]***

*Award **[3]** for correct final answer.*

(b) *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 CO_2;
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. hydrocarbons/VOCs/SVOCs **and** transport/solvents/industrial processes;
agrichemicals/pesticides/herbicides/fungicides;
polyaromatic hydrocarbons/PAHs **and** tar/coal/crude oil spills/incomplete combustion of wood/vegetation/waste incineration/industrial emission/waste;
polychlorinated biphenyls/PCBs **and** incinerator stacks/leaks from enclosed electrical equipment/leaks from hydraulic fluids/use as coolants;
organotin compounds **and** bactericides/fungicides/ship paints/stopping plants; ***[2 max]***
Need pollutant and its source for mark.
*Award **[1 max]** for two pollutants without sources.*

E5. $NO_2 + hf \rightarrow NO + O\bullet$;
$NO + O_3 \rightarrow NO_2 + O_2$;
$NO_2 + O\bullet \rightarrow NO + O_2$;
$O\bullet + O_3 \rightarrow 2O_2$; ***[3 max]***
No penalty for missing the free radical sign or using them on nitrogen oxides.
Accept other symbols in place of hf e.g. uv, hυ or light, in front of or above the arrow.

Option F — Food chemistry

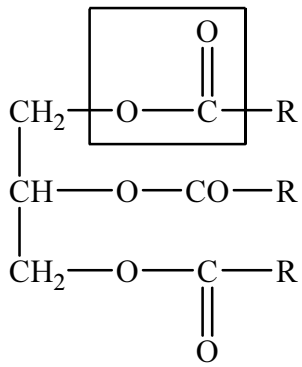
F1. (a) CH_2O ;

Accept $(CH_2O)_n$

one carbonyl/C=O **and** (at least two) hydroxyl/OH groups; ***[2]***

(b) (i) H_2NCH_2COOH ; ***[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) $C_{19}H_{39}COOH : 0$
$C_{19}H_{31}COOH : 4$
$C_{19}H_{29}COOH : 5$ ***[2]***
*All three **[2]**, any two **[1]**, any one **[0]**.*

(ii) $C_{19}H_{29}COOH$;
greatest/most number of C=C bonds / most unsaturated; ***[2]***
Accept: can react most easily with O_2 / H_2 */ light / enzymes / heat / water/hydrolysed.*

F2. *Initiation step*:
$RH \rightarrow R\bullet + H\bullet$;

Propagation step:
$R\bullet + O_2 \rightarrow ROO\bullet$;

Termination step:
$R\bullet + R\bullet \rightarrow RR$ / $R\bullet + ROO\bullet \rightarrow ROOR$ / $ROO\bullet + ROO\bullet \rightarrow ROOR + O_2$; ***[3]***
Allow R and H instead of $R\bullet$ *and* $H\bullet$ *in all of the above.*

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:
$HOCH_2(CH(OH))_4CHO + H_2NCHRCOOH \rightarrow H_2O + HOCH_2(CH(OH))_4CH{=}NCHRCOOH$; ***[4]***

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]***

F5. (a) L isomer;
molecule is viewed with C–H bond pointing away from observer/viewer and COOH, R/CH_3 and NH_2 (groups) are arranged anti-clockwise (around the asymmetric carbon atom); ***[2]***
Accept converse description.
Award M2 if there is reference to groups being arranged anti-clockwise without identifying the groups.

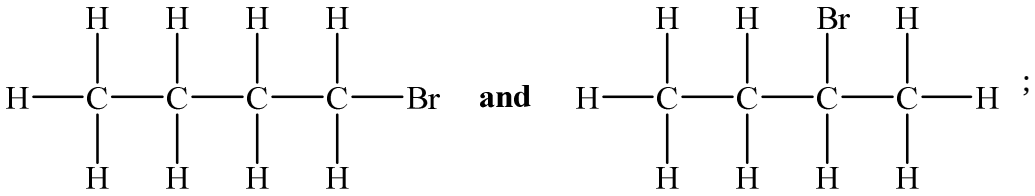
(b) *d* rotates plane of polarized light clockwise/dextrorotatory/+ / *l* rotates plane of polarized light anti-clockwise/laevorotatory/–; ***[1]***

F6. (a) contain alternate (carbon to carbon) single and double bonds / extensive delocalization/conjugation/π bonding;
absorb in the visible region **and** transmit complementary colour; ***[2]***

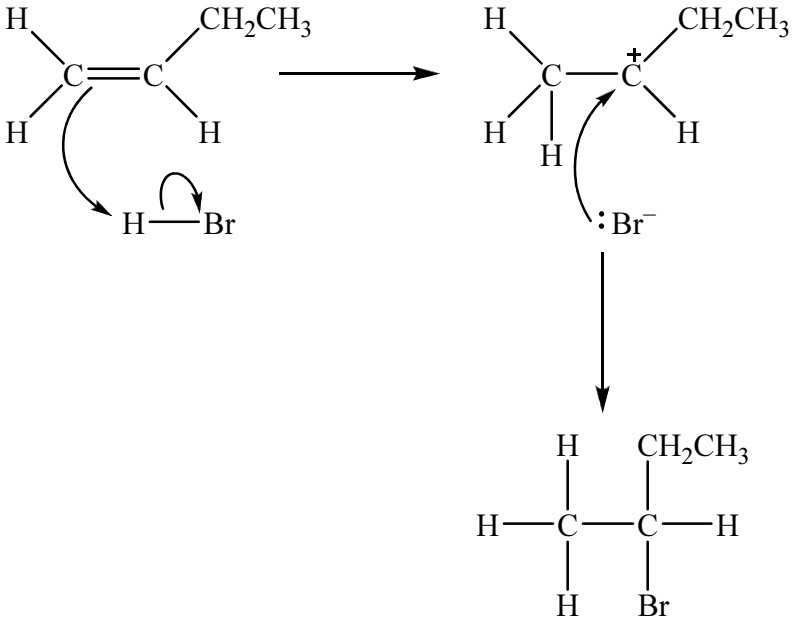
(b) *Anthocyanins*:
water soluble;

Carotenes:
fat soluble; ***[2]***

Option G — Further organic chemistry

G1. (a) (i)  **and** ; ***[1]***

Accept condensed structural formulas $CH_3CH_2CH_2CH_2Br$ and $CH_3CH_2CHBrCH_3$.

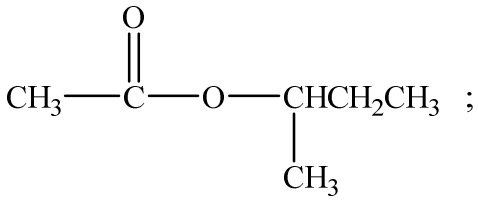
(ii) 

curly arrow from C=C bond to H of H—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 $CH_3CHBrCH_2CH_3$; ***[4]***
Award M1 and M2 if mechanism for the minor product given.

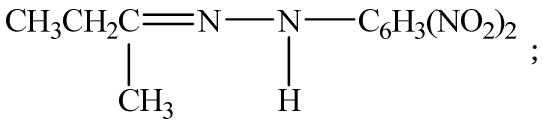
(iii) secondary/intermediate carbocation is more stable (than primary/intermediate carbocation);
carbocation is stabilized by two electron releasing groups/positive inductive effects (compared to primary carbocation); ***[2]***
No mark for stating due to Markovnikov's rule.

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

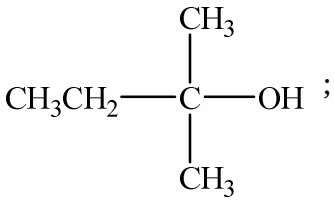
(ii) $CH_3COCl + CH_3CH_2CHOHCH_3 \rightarrow CH_3COOC_4H_9 + HCl$;
Accept molecular formulas.

 ;

[2]

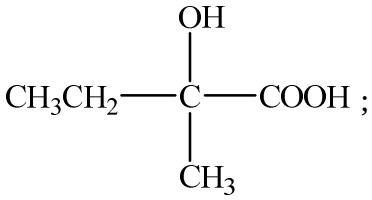
(c) (i)  ;

[1]

(ii)  ;

[1]

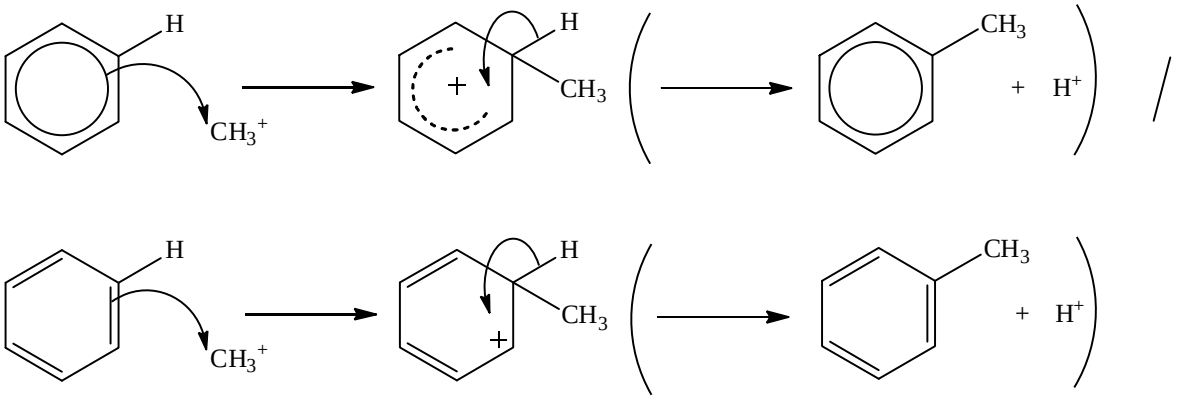
(iii) nucleophilic addition; ***[1]***

(iv)  ;

[1]

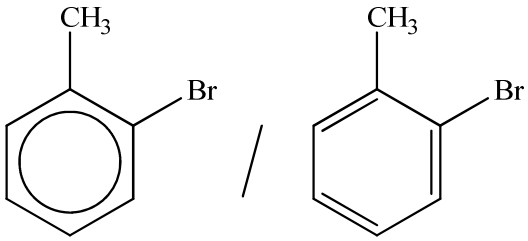
G2. dimethylamine > methylamine > ammonia;
methyl group has positive inductive effect / is an electron releasing group / increases the electron density of the non-bonding/lone electron pair on nitrogen;
two methyl groups in dimethylamine have greater effect than one methyl group in methylamine; ***[3]***

G3. (a) formation of the electrophile: $CH_3Br + AlBr_3 \rightarrow AlBr_4^- + CH_3^+$;

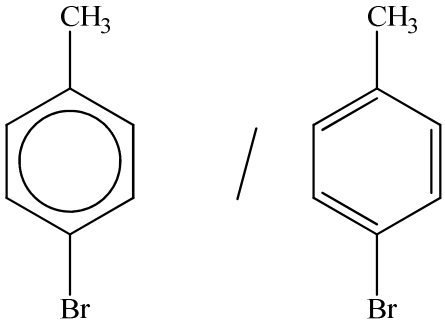


curly arrow from ring in benzene **or** from C=C bond in Kekule structure to CH_3^+;
curly arrow from C–H bond to positive charge on the intermediate **and** correct structure of the positive intermediate; ***[3]***

(b) (i)



OR



correct structure of 2-bromomethylbenzene/4-bromomethylbenzene; ***[1]***

(ii) methylbenzene reacts faster than benzene;
methyl group is electron releasing group/has positive inductive effect;
increases electron density of delocalized electrons/activates the ring;
resulting in stronger attraction of benzene ring towards electrophiles; ***[4]***