M10/4/CHEMI/HP3/ENG/TZ2/XX/M+

International Baccalaureate®
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MARKSCHEME

May 2010

CHEMISTRY

Higher Level

Paper 3

24 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 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. structure determination;
composition of substances;
determination of purity;
determination of amount/concentration of substance;
identification of substances; ***[2 max]***

A2. (a) light source emits wavelength of light that will be absorbed by the element/ Cu atoms / must be a Cu lamp / hollow cathode Cu lamp; ***[1]***

(b) sample is dehydrated / solvent/water is evaporated;
Cu^{2+} ions converted to Cu atoms / $Cu^{2+}(g) + 2e^- \rightarrow Cu(g)$ / Cu atoms are produced; ***[2]***

(c) make up different solutions of known concentrations (from the $0.10\ mol\,dm^{-3}\ CuSO_4$);
measure the absorbance for each concentration;
plot a calibration/absorbance against concentration curve;
read the value of unknown concentration from its absorbance / compare the absorption of the unknown with the standard solutions / *OWTTE*; ***[4]***

A3. (a) no change in dipole moment/bond polarity;
as vibration/stretching occurs; ***[2]***
Ignore bending if included.

(b) symmetrical stretching;
asymmetrical stretching;
bending/change in bond angle; ***[2 max]***
Accept diagrams of the water molecules which illustrate the bending and stretching.
*Allow **[1]** for stretching alone.*

A4. (a) *Chromatogram 2 should be:*
two broader peaks as chromatogram 1 for each peak;
two peaks of same area as chromatogram 1 for each peak;
two peaks of the same area as chromatogram 1 are closer to each other;
*Accept any one for **[1]**.*

eluted earlier; ***[2 max]***

(b)

Chromatographic technique	Stationary phase	Mobile phase
HPLC	Silica/silicon (di)oxide/SiO_2 and/or long chain hydrocarbon (on column);	hexane / water / alcohol / solvent / liquid;
GLC	Alkane / long chain hydrocarbon (on column);	$N_2(g)$ / $He(g)$ / $Ar(g)$;

[4]

Accept names of gases nitrogen, helium, argon.
Accept air or $H_2(g)$ as the mobile phase of GLC.
Do not accept inert gas for GLC.

(c) GLC; ***[1]***

(d) measure retention times for THG and sample;
if THG present in sample then (retention) times will be the same (under the same conditions);

OR

measure peak sizes for pure THG and mixture of THG and sample;
if THG present in sample then peak size greater for mixture (under same conditions); ***[2 max]***

A5. extensive conjugation of (C=C) double bonds / alternate single and double (carbon–carbon) bonds / involving delocalization of π electrons;
less energy is required (to excite the electrons);
absorption occurs in the visible region; ***[3]***

Option B — Human biochemistry

B1. $\Delta T = (29.0 - 20.5)/8.5(^{\circ}\text{C})$;

energy (released by dry bread) $= 600 \times 4.18 \times 8.5 = 21318/2.1 \times 10^4$ (J);

energy (released by 100 g of dried bread) $= 21318 \times 50 = 1065900/1.1 \times 10^6$ (J);

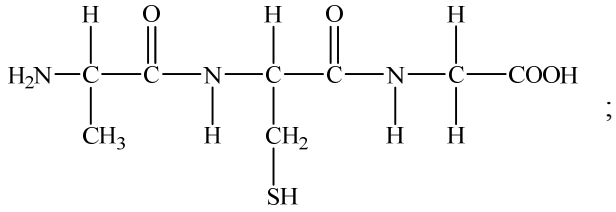
energy released $= \frac{1065900}{1000} = 1.1 \times 10^3$ (kJ per 100 g); ***[4]***

*Award **[4]** for correct final answer.*

B2. (a) structure / growth / repair
enzymes
hormones
transport
immunoproteins/antibodies
energy source ***[2 max]***

***Two** functions score **[1]**.*

(b)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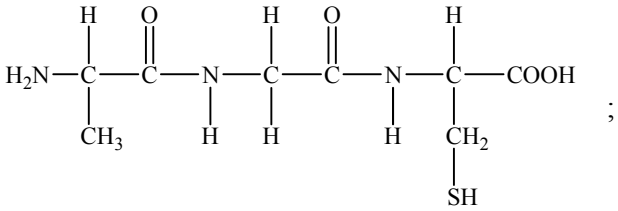
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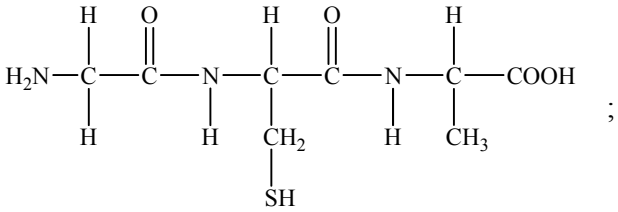
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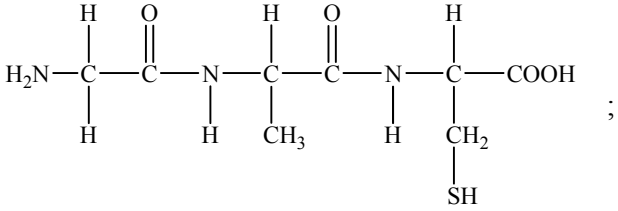
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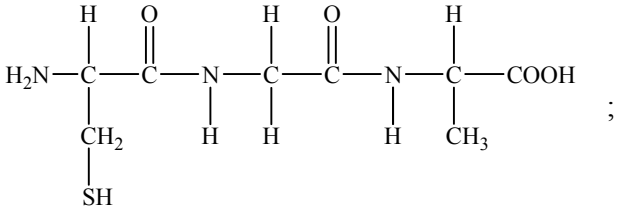
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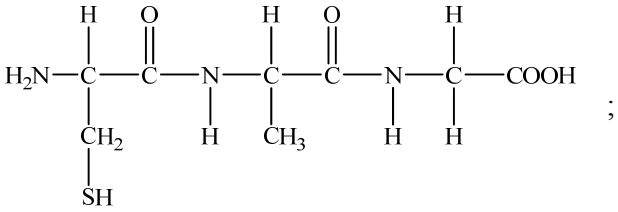
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[2 max]

Accept CONH for peptide bond.
Penalize incorrect representation of peptide bond (e.g. COHN) once only.

(c)

Structure	Bonding responsible for stabilizing structure
Primary	covalent; *Accept peptide/amide bond.*
Secondary	hydrogen / H-bonding;

[2]

(d) secondary structure folds to form a (unique) 3-D/dimensional structure of the protein;

Structure stabilized by:
disulfide bridges / covalent bonds between two S atoms (in cysteine)
hydrogen/H-bonding
ionic bonds / salt bridges
van der Waals'/dispersion/London forces ***[2 max]***
***Two** bond types score **[1 max]**.*

B3. (a) (mainly) plant material/cellulose not hydrolysed by (human) enzymes / plant material not digested (by humans) / *OWTTE*; ***[1]***

(b) provides bulk for the alimentary canal (muscles to stay healthy) / *OWTTE*;

diverticulosis
irritable bowel
constipation
obesity
Crohn's disease
hemorrhoids
diabetes mellitus/Type 2 diabetes ***[2 max]***
*Accept any **two** of the conditions or a description of the two conditions for **[1]**.*

B4.

$n(I_2)$	:	n(linolenic acid)
$\frac{7.7\text{ g}}{2\times 126.90\text{ g mol}^{-1}}$	:	$\frac{2.8\text{ g}}{278.48\text{ g mol}^{-1}}$ /
0.030 mol	:	0.010 mol;
(3	:	1)

3 C=C double bonds; ***[2]***
*3 C=C double bonds scores **[2]**.*
No ECF.

B5. *In aerobic respiration:*
glucose undergoes oxidation (and is converted to pyruvate ions);
(pyruvate ions) in the presence of oxygen are converted to carbon dioxide and water;

In anaerobic respiration:
pyruvate ions are reduced to lactate ions (due to the insufficient oxygen supply) / $C_6H_{12}O_6 \rightarrow 2CH_3CH(OH)COOH$;

aerobic respiration produces more energy / anaerobic produces less energy;
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$; ***[5]***

B6. DNA is double-strand nucleic acid / RNA is single-strand nucleic acid;
DNA (base) is thymine / RNA (base) is uracil;
DNA has deoxyribose as pentose sugar / RNA has ribose; ***[3]***
Accept suitable diagrams.
Do not accept U for uracil or T for thymine.

Option C — Chemistry in industry and technology

C1. (a) 1 nm to 100 nm; ***[1]***

(b) physical techniques move atoms to a specific position;
chemical techniques involve chemical reactions to position atoms (in molecules); ***[2]***
Accept suitable examples for chemical techniques.

(c) reference to effect on human health (*e.g.* unknown, immune system may not cope, unsatisfactory toxicity regulations);
reference to effect on employment (*e.g.* increased/decreased job opportunities, adverse effect on traditional industries);
reference to effect on quality of life (*e.g.* medical advances, faster computers, improved performance of electronic equipment);
reference to public opinion (*e.g.* need to improve information, encourage discussion, seek approval);
reference to nanotechnology being developed in wealthier nations hence increasing the divide between different nations; ***[2 max]***

C2. (a) *Accept **two** of the following four pairs of answers.*

plasticizers in polyvinyl chloride;
the more plasticizer the more flexible the plastic;

OR

volatile hydrocarbons in the formation of (expanded) polystyrene;
volatile hydrocarbons vaporize during the formation of the polystyrene and reduce the density of (expanded) polystyrene / improving insulating properties;

OR

sulfur added to diene/2-methyl-1,3-butadiene/rubber (produces cross-link polymer);
maintains its spring/softness (for longer periods of time);

OR

blowing air/steam during polymerisation to form polyurethane;
reduces density/increases springiness; ***[4 max]***

(b) *Advantages:*
polymer's properties can be customized / *OWTTE*
can be recycled/reused
cheap
chemically inert
transparent
non-toxic
*Any **two** correct answers scores **[1].***

Disadvantages:
rely on non-renewable energy sources
volume occupied by plastics in landfill
non-biodegradability
burning produces toxic gases
burning produces carbon dioxide (greenhouse gas)
burning printed polyethene can release toxic (heavy) metals/substances
may cause suffocation/death of animals ***[2 max]***
*Any **two** correct answers scores **[1].***

C3. (a) soap / kevlar / fatty acids / lipid bilayer / cellulose / silk proteins / DNA;

lyotropic liquid crystals
solutions that show the liquid-crystal state at certain concentrations;

thermotropic liquid crystals
(pure substances that) show liquid-crystal behaviour over temperature ranges (between the solid and liquid states); ***[3]***

(b) biphenyl nitriles/cyanobiphenyls; ***[1]***

(c) nitrile groups make molecule polar;
intermolecular forces are strong enough to align in a common direction;
biphenyl groups make molecules more rigid/rod-shaped;
(long) alkane chain ensures that molecules cannot pack together closely (to maintain liquid-crystal state); ***[4]***

C4. (a) permeable to Na^+ ions only; ***[1]***

(b) membrane cell has a polymer membrane **and** diaphragm cell has an asbestos membrane;
membrane cell allows only Na^+ ions to pass through **and** diaphragm cell allows both Na^+ and Cl^- ions through;
NaOH solution is purer in membrane cell **and** contaminated with NaCl in diaphragm cell; ***[2 max]***

(c) *Mercury cell*
Hg losses enter the environment (through the cell effluent) / forms organo-mercury compounds / poses health hazard when consumed through mercury contaminated fish / causes Minamata disease / can cause kidney failure / damage to brain/CNS;

Diaphragm cell
asbestos poses health problems;

Membrane cell
more efficient / produces higher purity/concentration of NaOH; ***[3]***
No mark for no mercury or asbestos in membrane cell.

Option D — Medicines and drugs

D1. (a) C; ***[1]***

(b) A / B / A **and** B; ***[1]***

(c) A; ***[1]***

D2. alter cells genetic material so that virus cannot use it to multiply;
prevent viruses from multiplying by blocking enzyme activity within host cell / inhibit the synthesis of viral components by blocking enzymes inside the cell;
prevent viruses from entering (human) cell / bind to cellular receptors targeted by viruses / bind to virus-associated proteins/VAPs which target cellular receptors;
prevent/hinder the release of viruses from the cell; ***[2 max]***

D3. (a) *Mild analgesics:*
suppress the production of prostaglandins/pain-sensitizing substances / intercept the pain stimulus at the source;

Strong analgesics:
bind to (opioid) receptors in the CNS/central nervous system/brain / suppress the transmission of pain impulses to the brain / *OWTTE*; ***[2]***

(b) *Advantages:* ***[2 max]***
strong(er) analgesics / relieve acute/extreme pain;
wide therapeutic window / *OWTTE*;
relieve anxiety / induce relaxation / improve the quality of life;
intravenous/faster distribution of drug;

Disadvantages: ***[2 max]***
euphoria / lack of self-control / dangerous behaviour;
addiction/dependence / withdrawal symptoms;
tolerance / increased risk of overdose upon prolonged use;
kidney/renal failure;
risks associated with intravenous drug administration; ***[4 max]***

Accept other side-effects (including drug-specific for different opiates).

(c) molecule of heroin is <u>less polar</u> / molecule of morphine is <u>more polar</u> / <u>polar</u> OH groups in morphine are replaced with <u>less polar/non-polar</u> groups in heroin;
(less polar molecules) cross the blood-brain barrier faster/more easily / (heroin) is more soluble in non-polar environment of the CNS/central nervous system than morphine / *OWTTE*; ***[2]***

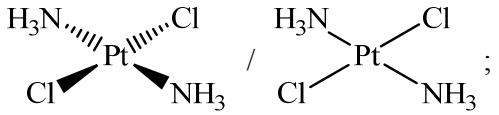
D4. (a) diazepam/Valium®;
nitrazepam/Mogadon®;
alcohol/ethanol; ***[3]***
Accept other correct depressants.

(b) sedation/relaxation/soothing/reduction of anxiety/reduces heart rate / blood vessels dilate / *OWTTE*; ***[1]***
Accept sleepiness.

D5. (a) large number of similar/structurally related compounds;
(synthesized) automatically/semi-automatically / on a small/micro scale;
(using) solid-phase techniques/resin beads;
same reaction sequence is applied at the same time to many compounds/targets;
*Award **[3 max]** for the above points.*

combinatorial synthesis produces larger/more diverse libraries / parallel synthesis produces smaller/more focused libraries;
combinatorial synthesis is performed in the same reaction vessel/using mix and split technique / parallel synthesis is performed in different reaction vessels; ***[4 max]***
Allow OWTTE in all cases.

(b) molecular/3-D modelling of receptors/pharmacophores/binding sites/potential drugs/drug-receptor interactions / virtual synthesis of drugs;
facilitation of rational/target-oriented drug development/drug design / evaluation of (biological/pharmacological) effects of new drugs; ***[2]***

D6. 

;

Accept NH_3- instead of H_3N-

geometrical / *cis*-, *trans*-; ***[2]***

Option E — Environmental chemistry

E1. (a) methane / CH_4;
nitrous oxide / N_2O;
ozone / O_3;
chlorofluorocarbons/CFCs / specific CFC / halocarbon / hydrochlorofluorocarbons/HCFCs;
sulfur hexafluoride / SF_6; ***[2 max]***

(b) greenhouse gases/named gas(es) are transparent to/allow to pass through short(er)-wavelength/high(er)-energy radiation/UV light from Sun / *OWTTE*;

greenhouse gases/named gas(es) absorb long(er)-wavelength/IR radiation from Earth / *OWTTE*;
(part of) absorbed radiation is re-radiated to Earth / *OWTTE*; ***[3]***
Do not allow trap or reflected.

(c) droughts – food production decreases;
more rainfall – food production increases / may lead to flooding so decrease in food production;
warmer climate – food production increases;
severe weather / excessive rainfall / very hot climate – food production decreases;
deserts increase in size – food production decreases;
pests/insects multiply/spread over larger areas – food production decreases; ***[3 max]***
Allow other reasonable assumptions.
No mark if the effect on food/crop/plants is not explicitly stated.

E2. (a) *Low-level waste:*
radiotherapy/radiodiagnostics / food/seed/plant irradiators / smoke detectors / radiation laboratories / uranium mill tailings / (supporting processes of) nuclear fuel cycle;

High-level waste:
(main processes of) nuclear fuel cycle / nuclear weapons / radioisotope thermoelectric generators; ***[2]***
Accept more specific processes/devices/etc. for both high and low level waste.
Do not accept radioactive elements/isotopes without references to their sources.

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

(ii) A; ***[1]***

(iii) B; ***[1]***

E3. (a) hydrocarbons
(per)fluorocarbons
hydrofluorocarbons / HFCs
hydrochlorofluorocarbons / HCFCs
ammonia/ NH_3 / sulfur dioxide/ SO_2
nitrogen/ N_2 / argon/Ar ***[1 max]***
*Any two correct answers scores **[1].***

(b) flammability (of hydrocarbons);
(limited) ozone-depleting properties (of HCFCs);
greenhouse properties (of methane/fluorocarbons/hydrofluorocarbons/HCFCs);
toxicity (of NH_3/SO_2 /some HCFCs);
high(er) pressure/danger of explosion (when using compressed/liquid gases);
(many CFCs alternatives are) less efficient solvents than CFCs; ***[2 max]***
Allow OWTTE in all answers.

(c) $O_3 + NO \rightarrow O_2 + NO_2$;
$NO_2 + O\bullet \rightarrow NO + O_2$; ***[2]***
Accept species with or without radical symbol.

(d) bond in O_2 is <u>stronger</u> than the bonds in O_3 / bond in O_3 is <u>weaker</u> than the bond in O_2 ;
in O_2 bond is double/bond order is 2 **and** bonds in O_3 are intermediate between single and double/have an order of 1.5;
energy of light/photon depends on wavelength / *OWTTE*;
energy of light/photon with $\lambda = 300–330$ nm is insufficient to break bonds in O_2 but enough to break bonds in O_3 / *OWTTE*; ***[3 max]***

E4. (a) bowl-shaped/valley location / *OWTTE*;
*Any **two** of the following:*
VOCs **and** NO_x in the atmosphere / *OWTTE*;
sunlight / UV radiation / *OWTTE*;
no wind / limited air circulation / temperature inversion / layer of warm air over cold air / *OWTTE*; ***[3 max]***

(b) $CH_3C(O)OO\bullet + NO_2 \rightarrow CH_3C(O)OONO_2$; ***[1]***
Brackets around O not required.
Accept any other group instead of CH_3 including R.
Accept species with or without radical symbol.

Option F — Food chemistry

F1. (a) shelf life is the time (after which) a food no longer maintains the expected quality (desired by the consumer) / *OWTTE*;
because of spoilage / changes in flavour/smell/texture/appearance (colour, mass) / *OWTTE*; ***[2]***

(b) *Any **two** of the following for **[2]** marks each:*

water content / moisture;
loss of nutrients / browning / rancidity / microbial spoilage;

OR

pH;
unpleasant/off flavours / colour change/browning / loss of nutrients;

OR

light;
rancidity / vitamin loss / colour fading / nutrient loss / off-flavours;

OR

temperature;
increased rate of spoilage;

OR

contact with air;
oxidation of food / browning / nutrient loss; ***[4 max]***

F2. (a) unsaturated fatty acid has (3) C=C double bonds;
saturated fatty acid has only single C–C bonds;
unsaturated fatty acid can display *cis* and *trans* isomerism / saturated fatty acid cannot display *cis* and *trans* isomerism;
saturated fatty acid chains are straighter than unsaturated chains / *OWTTE*; ***[3 max]***

(b) hydrogen/ H_2 /hydrogenation;
(high pressure and) high temperature/any temperature in the range 150 °C to 200 °C /heat;
catalyst/nickel/Ni/platinum/Pt/copper/Cu/zinc/Zn; ***[3]***

(c) semi-solid/solid fat/lipid (with higher melting point);
decreased rate of oxidation / stability increases with increasing saturation;
increased hardness;
control feel and plasticity/stiffness;
hydrogenated vegetable fats are cheaper than animal fats; ***[1 max]***

F3. (a) a substance that delays the onset/slows the rate of oxidation;
extends the shelf life of food / reduces rancidity; ***[2]***
Do not accept prevent.

(b) *Natural antioxidants:* ***[1 max]***
add unwanted colour to food;
(may) add unwanted (after)taste to food/off flavour;
may be less effective at extending shelf life / *OWTTE*;

Synthetic antioxidants: ***[1 max]***
perceived less safe by consumers;
food additives need to be regulated to ensure safety;
regulating/labelling of food additives difficult/inconsistent between countries; ***[2 max]***

(c) *Reducing agents*
electron donors/remove oxygen;
vitamin C/ascorbic acid/carotenoids;

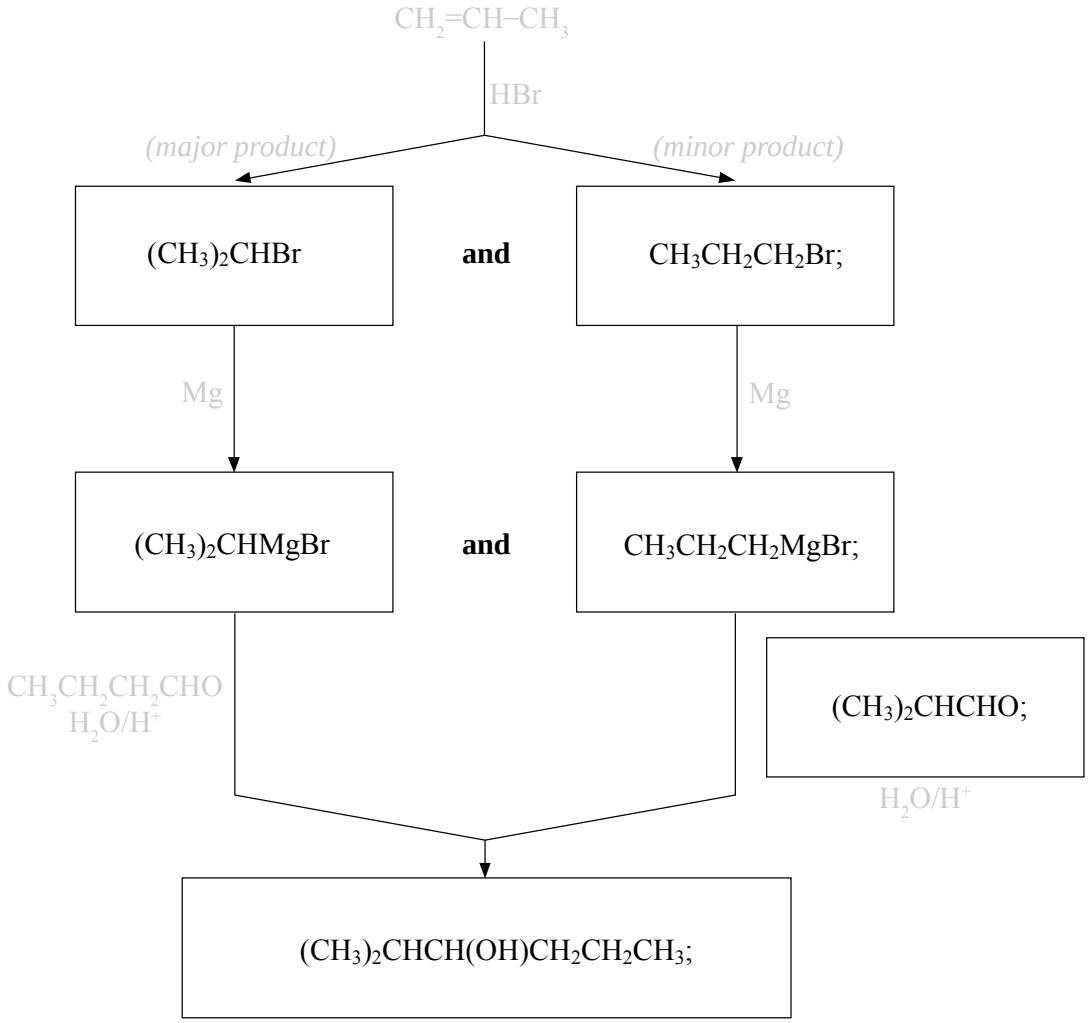
Chelating agents
reduce the concentration of (free) metal ions in solutions;
plant extracts/rosemary/tea/ground mustard; ***[4]***

F4. *Anthocyanins*
have (several) –OH groups / forms H–bonding with water;
water-soluble;

Carotenoids
(mostly) non-polar;
fat-soluble; ***[4]***

Option G — Further organic chemistry

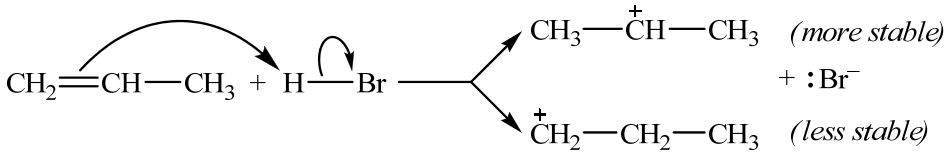
G1. (a)



[4]

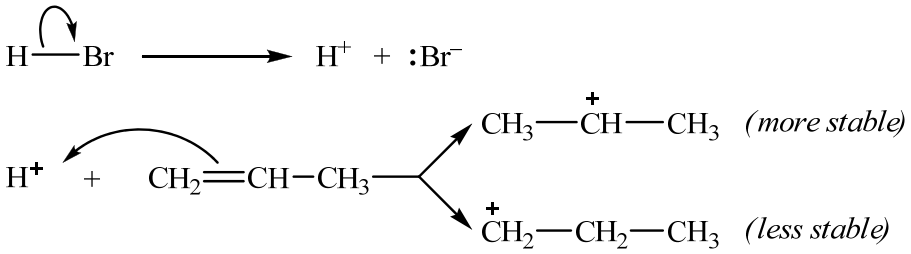
Allow ECF if major and minor products are interchanged.
Allow more detailed formulas throughout the option.

(b)

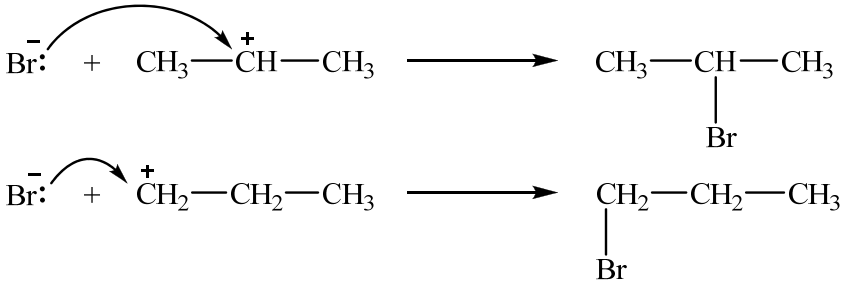


curly arrow showing movement of electron pair from the double bond to **hydrogen** in HBr;
formation of Br^-;

OR



equation for HBr dissociation, including the curly arrow;
curly arrow showing movement of electron pair from the double bond to H^+;



correct structures of **both** carbocations;
curly arrow showing either C–Br bond formation / mechanism for either product;

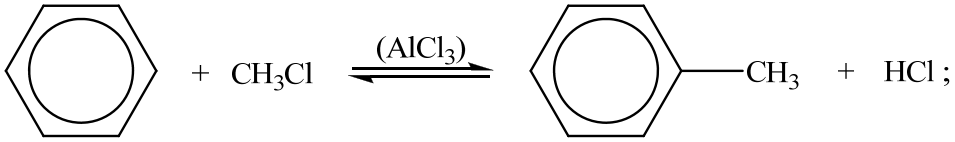
*Award **[3 max]** for mechanism.*

$(CH_3)_2CH^+$ is more stable / $CH_3CH_2CH_2^+$ is less stable; ***[4 max]***

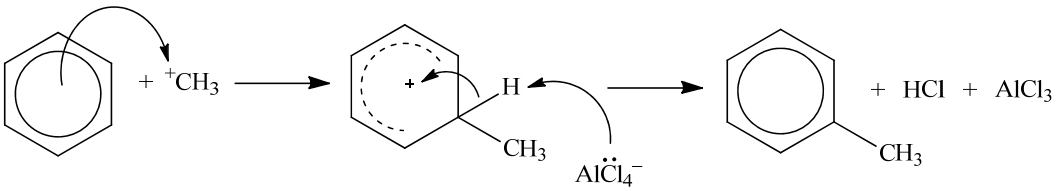
G2. (a) increases acidity / *OWTTE*;
increases stability of conjugate ion;
halogens are electron acceptors / halogens withdraw/pull electrons / halogens are more electronegative than carbon;
(acceptors) increase O–H bond polarity / increase δ^+ on H / decrease O–H bond strength / favour dissociation of O–H bond / *OWTTE*; ***[3 max]***

(b) chloroethanoic acid > 3-chloropropanoic acid > propanoic acid / *OWTTE*; ***[1]***

(c) any pK_a value or range of values within the range 2.87– 4.86; ***[1]***
The actual pK_a value is 3.98.

G3. (a) 

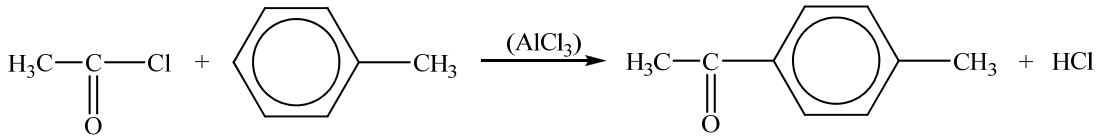
[1]
Accept C_6H_6 and $C_6H_5CH_3$ instead of their structural formulas.
Equilibrium sign and Lewis acid not required for mark.
Accept other workable Lewis acids e.g. $FeCl_3$.

(b) 

curly arrow going from delocalized electrons in benzene to $^+CH_3$;
Do not penalize if CH_3^+ is written.

representation of carbocation with correct formula and positive charge on ring;
curly arrow going from lone pair/negative charge on Cl in $AlCl_4^-$ to H **and** curly arrow going from CH bond to benzene ring;
formation of organic product methylbenzene **and** HCl **and** $AlCl_3$; ***[4]***
Allow mechanism with corresponding Kekulé structures.

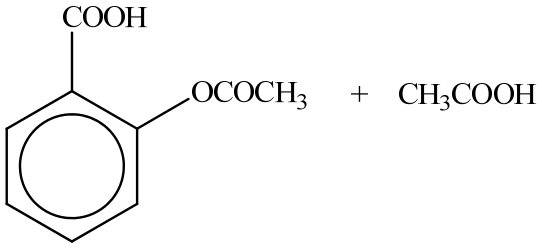
G4. (a)



correct structural formulas of reactants, condensed or displayed;
correct structural formula, condensed or displayed, of (4-methylphenyl)ethanone; ***[2]***
Accept 2-methyl isomer.

(b) sterical hindrance of the methyl group / CH_3 is bulky enough to prevent substitution at 2- and 6-positions / *OWTTE*;
CH_3 is a (weakly) electron-releasing/Type I substituent / directs substitution to 2-, 4- and 6-positions / stabilises σ-complexes with sp^3 hybrid carbon in *ortho*- and *para*-positions / *OWTTE*;
CH_3CO is an electron-withdrawing/deactivating/Type II substituent (which) prevents/decreases the rate of further substitution / *OWTTE*; ***[2 max]***

G5.



correct structural formula of acetylsalicylic acid;
correct structural formula of ethanoic acid;
Accept condensed formula for ethanoic acid.

addition-elimination / condensation / esterification / nucleophilic substitution; ***[3]***