M10/4/CHEMI/SP3/ENG/TZ2/XX/M+

MARKSCHEME

May 2010

CHEMISTRY

Standard Level

Paper 3

21 pages

Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

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

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

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

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

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

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

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

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

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

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

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

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

e.g. if the answer is 1.63:

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

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

12. If a question specifically asks for the name of a substance, do not award a mark for a correct formula, similarly, if the formula is specifically asked for, do not award a mark for a correct name.

13. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.

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

Option A — Modern analytical chemistry

A1. 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) only allows the particular/specific/required wavelength/frequency/colour to pass through; ***[1]***

(d) 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) *Stationary phase:*
water in the paper;

Mobile phase:
water / any other non corrosive solvent or solvent mixture; ***[2]***

(b) (i) $R_f = \dfrac{\text{distance moved by substance}}{\text{distance moved by solvent / solvent front}}$; ***[1]***

(ii) $R_f = \dfrac{3.0}{5.7} = 0.53$; ***[1]***

Accept answers between 0.5 and 0.55 (± 1mm on measurements).

(c) compare R_f of unknown to known values;
(conducted) under the same conditions (of stationary/mobile phase); ***[2]***
Allow second mark for specifying a particular condition to keep the same (e.g. solvent).

A4. (a) no change in dipole moment/bond polarity;
as vibration/stretching occurs;
Ignore bending if included. ***[2]***

(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.*

Option B — Human biochemistry

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

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) ;

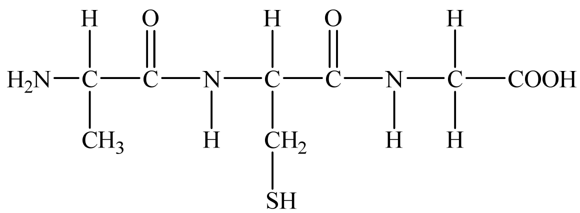
energy released $= \dfrac{1065900}{1000} = 1.1 \times 10^3$ (kJ per 100 g) ; ***[4]***

*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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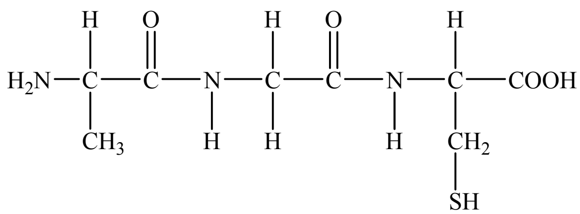
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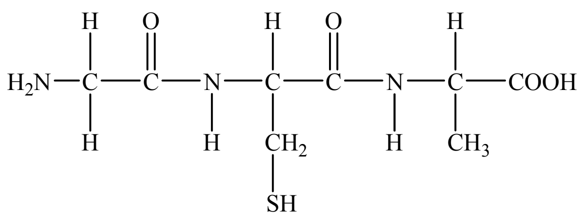
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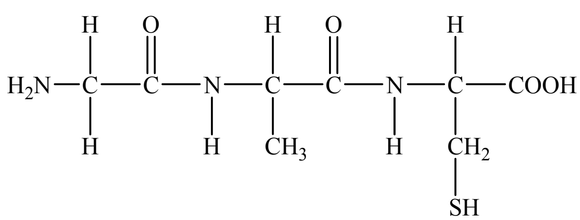
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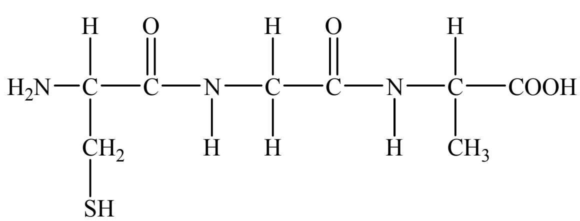
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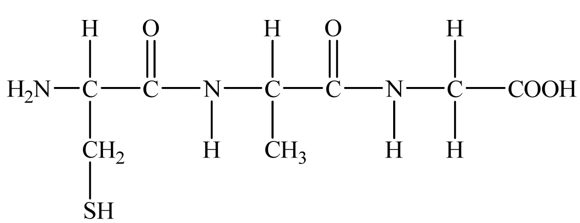

;

[2 max]

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

(c) 6; ***[1]***

(d)

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

[2]

(e) 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. (a) chemical messenger;
secreted directly into the blood by endocrine glands; ***[2]***
Accept pituitary gland, pancreas, ovaries, testes, thyroid gland and adrenal gland with the corresponding hormone.

(b) build up depleted muscle due to lack of activity;
assist in recuperation from an illness;
stimulation of bone marrow;
treatment of delayed male puberty;
asthma inhalers;
treatment of female-to-male gender changes;
treatment of inflammation;
*Award **[1]** for any one use.*

muscle/strength build up for an unfair advantage in sport by athletes; ***[2 max]***
*Award **[1]** for abuse.*

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) hematite, Fe_2O_3;
magnetite, Fe_3O_4 / $FeO{\bullet}Fe_2O_3$;
goethite, FeO(OH);
limonite, $Fe_2O_3{\bullet}H_2O$; ***[1 max]***
*Award **[1]** for any one name and its formula.*

(b) (i) $Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(l) + 3CO_2(g)$ /
$Fe_3O_4(s) + 4CO(g) \rightarrow 3Fe(l) + 4CO_2(g)$ /
$Fe_2O_3(s) + 3C(s) \rightarrow 2Fe(l) + 3CO(g)$ /
$2Fe_2O_3(s) + 3C(s) \rightarrow 4Fe(l) + 3CO_2(g)$ /
$Fe_3O_4(s) + 4C(s) \rightarrow 3Fe(l) + 4CO(g)$ /
$Fe_3O_4(s) + 2C(s) \rightarrow 3Fe(l) + 2CO_2(g)$; ***[1]***
Accept appropriate equations with goethite and limonite.

(ii) $CaO(s) + SiO_2(s) \rightarrow CaSiO_3(l)$ / $CaO(s) + Al_2O_3(s) \rightarrow CaAl_2O_4(l)$; ***[1]***

C3. (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 the polymerisation to form polyurethane;
reduces density/increases springiness ***[4 max]***

(b) high degree of branching produces low density polyethene;
small degree of branching produces high density polyethenes;
HDPE/low branching is stiffer/stronger/more resistant to heat and corrosion/less permeable to gases / LDPE/high branching is more flexible/weaker/less resistant to heat and corrosion/more permeable to gases; ***[3]***

(c) *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]**.*

C4. 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]***

Option D — Medicines and drugs

D1. *Differences:*
(two) hydroxy(l)/alcohol and phenol groups are esterified/replaced with ester/ethanoate/acet(yl)oxy groups / *OWTTE*;
Accept formulas instead of group names.

Functional groups: ***[2 max]***
hydroxy(l)/alcohol/phenol;
ether/oxa;
(tertiary) amine/amino;
double bond/alkene;
aromatic/benzene ring/phenyl/aryl; ***[3 max]***

D2. (a) bacteria are self-reproducing units while viruses are not / viruses need living hosts/cells to multiply / *OWTTE*;
bacteria are able to grow/metabolise/feed and excrete / viruses lack metabolic functions;
bacteria contain various cell subunits/organelles/cell wall (performing specific functions) / viruses consist only of genetic material and protective coating;
bacteria are (many times) larger than viruses / viruses are smaller than bacteria;
bacteria have more complex DNA / viruses have simpler DNA;
viruses mutate/multiply (much) faster than bacteria / bacteria mutate/multiply slower than viruses; ***[2 max]***
If comparative term used e.g. smaller what it's compared to is not required.

(b) 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]***

(c) viruses mutate quickly so adapt to drugs/evade immune system response / *OWTTE*;
bacteria are more complex and thus can be targeted in more ways / viruses lack subunits/functions targeted by antibacterials / *OWTTE*;
bacteria can be killed/impaired by simple chemical agents / viruses cannot be killed and must be targeted on genetic level / *OWTTE*;
different types of bacteria employ similar metabolic processes and thus can be targeted by common antibacterials / each kind of virus usually requires special drugs/approaches / *OWTTE*; ***[3 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).

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

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

Option E — Environmental chemistry

E1. (a) methane / CH_4 ;
nitrous oxide / N_2O ;
ozone / O_3 ;
sulfur hexafluoride / SF_6 ;
chlorofluorocarbons/CFCs / specific CFC / halocarbon / hydrochlorofluorocarbons/HCFCs; ***[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 accept reflected or trapped.

(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/crops/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) *Step 1:*
$O_3 + hv \rightarrow O_2 + O\bullet$;

Step 2:
$O\bullet + O_3 \rightarrow 2O_2$; ***[2]***

Dots and radicals are not required for the mark.
Accept more detailed mechanisms $(O\bullet + O_2 + M \rightarrow O_3 + M^*, etc.)$.

(b) 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]****.*

E4. *Award* ***[2]*** *for any two of the three types.*
Salinization
salts are brought to soil by irrigation/watering / salts remain in soil after water evaporates;
plants cannot grow if soil is too salty;

Nutrient depletion
harvesting removes nutrients from soil / disrupts (re)cycling of nutrients;
reduced productivity of soil;

Soil pollution
caused by use of fertilisers/pesticides/chemicals;
reduced biodiversity / contamination of surface/ground water; ***[4 max]***

Allow OWTTE in all cases.

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) <u>C=C</u> double bonds;
saturated fatty acid has only single <u>C–C</u> 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 of $150\ ^\circ C$ to $200\ ^\circ C$ /heat;
catalyst/nickel/Ni/platinum/Pt/copper/Cu/zinc/Zn; ***[3]***

(c) (i) 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]***

(ii) *(trans fatty acids can be formed from partial hydrogenation of fats and oils)*
(trans fatty acids) are difficult to metabolize/accumulate in fatty tissue/are difficult to excrete;
(trans fatty acids) increase the levels of LDL cholesterol;
(trans fatty acids) are a low quality energy source;
mono- and poly-unsaturated fats are healthier (for the heart) than saturated fats / *OWTTE*; ***[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 "prevents rancidity".

(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*;

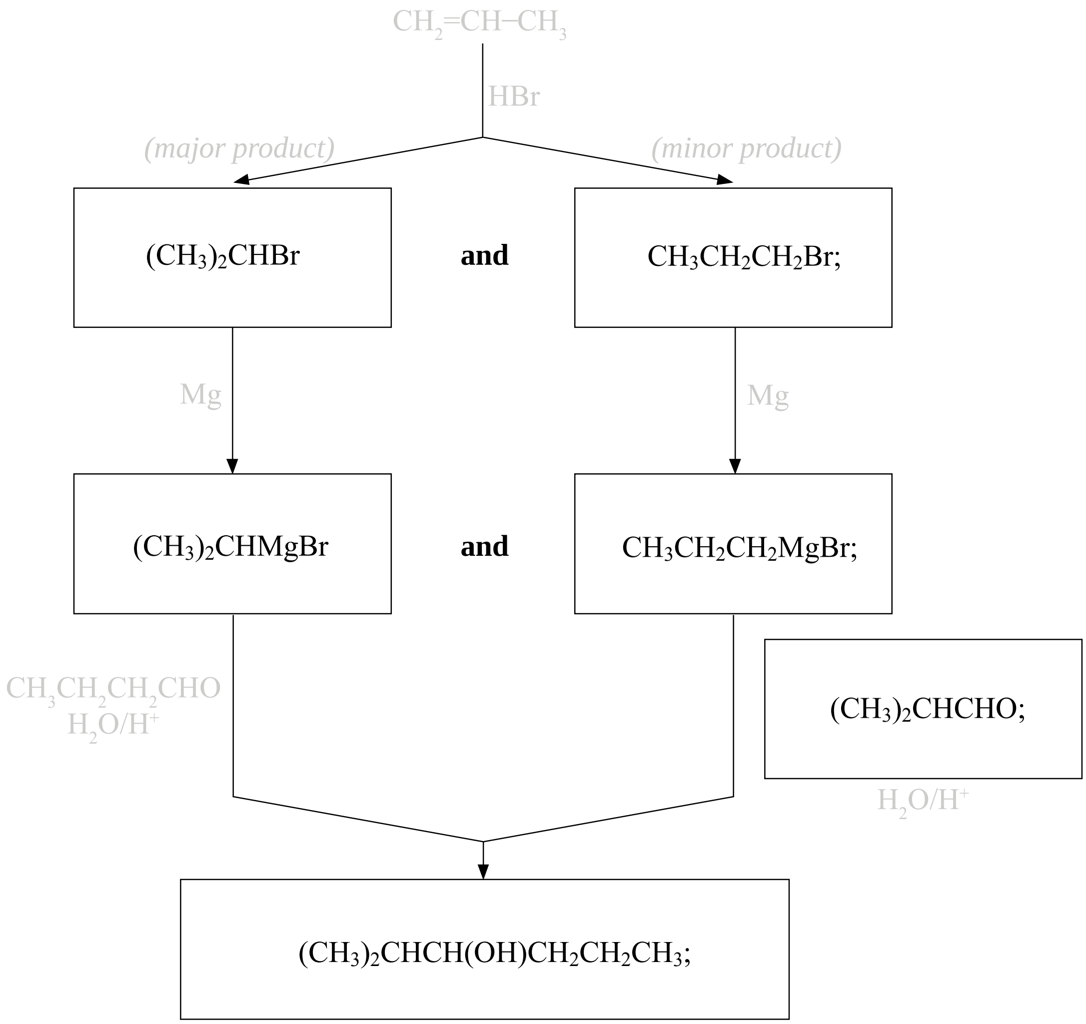
Synthetic antioxidants: ***[1 max]***
perceived less safe by consumers;
food additives that need to be regulated to ensure safety;
regulating/labelling of food additives difficult/inconsistent between countries; ***[2 max]***

F4. *pigment*
naturally found in plants/animals;

dye
synthetic; ***[2]***

Option G — Further organic chemistry

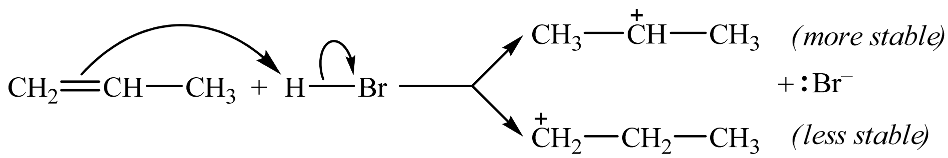
G1. (a)



[4]

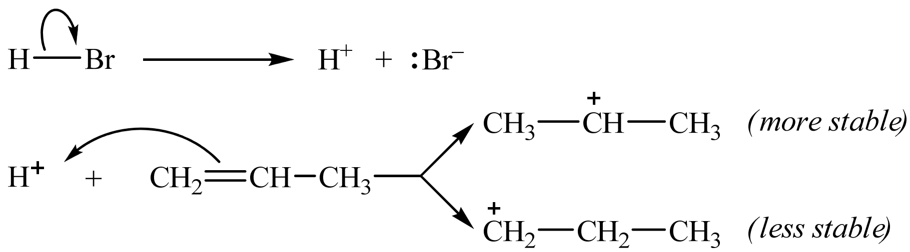
Allow ECF if major and minor products are interchanged.
Allow more detailed formulas throughout the option.

(b)

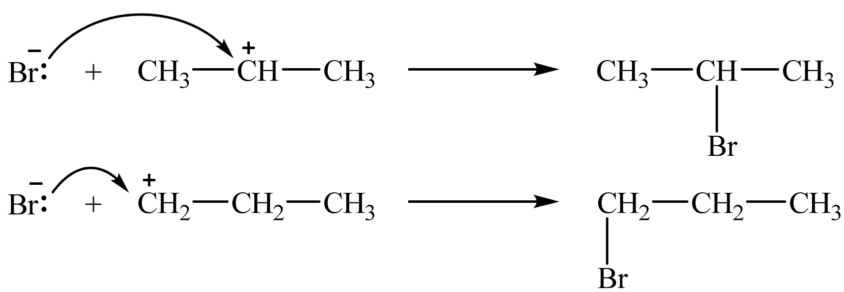


curly arrow showing movement of electron pair from the double bond to **hydrogen** in HBr;
formation of Br^-;

OR



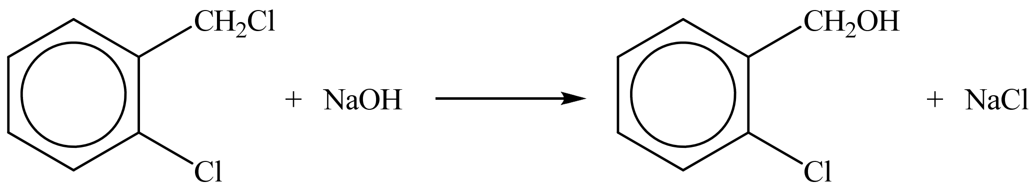
equation for HBr dissociation;
curly arrow showing movement of electron pair from the double bond to H^+;



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. 

correct formulas of the reactants **and** the inorganic product;
correct formula of the organic product; ***[2]***

G3. *Step 1:*

$CH_3CH_2CH_2CH_2OH \xrightarrow{H^+,\text{ heat}} CH_3CH_2CH{=}CH_2 + H_2O$;

Accept H^+, concentrated H_3PO_4 or concentrated H_2SO_4 as catalyst.

Reaction type for Step 1:
elimination/E / dehydration;

Step 2:

$CH_3CH_2CH{=}CH_2 + Br_2 \longrightarrow CH_3CH_2CHBrCH_2Br$;

Reaction type for Step 2:
electrophilic addition/ A_E; ***[5]***
Allow more detailed formulas.

G4. (a) increases acidity / *OWTTE*;
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*;
increases the stability of the conjugate ion; ***[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.