



MARKSCHEME

May 2009

CHEMISTRY

Standard Level

Paper 3

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Subject Details: Chemistry SL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the options [**2 × 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	<i>reject</i>
1.6	<i>accept</i>
1.63	<i>accept</i>
1.631	<i>accept</i>
1.6314	<i>reject</i>

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

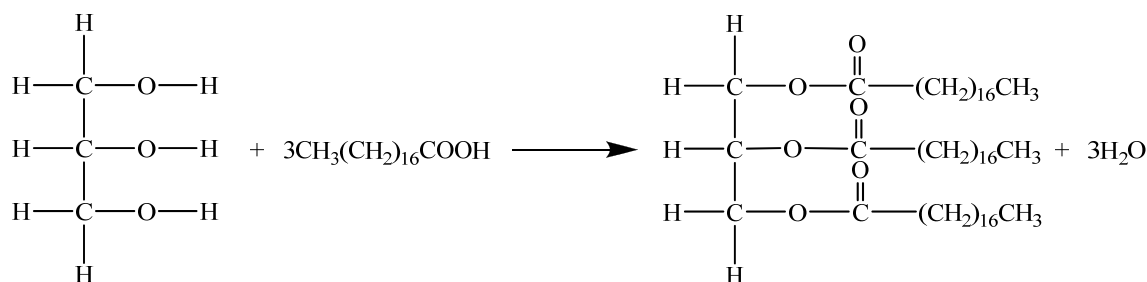
12. If a question specifically asks for the name of a substance, do not award a mark for a correct formula, similarly, if the formula is specifically asked for, do not award a mark for a correct name.
13. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, 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.** (a) determination of structure (of a substance/compound);
determination of the purity (of a substance/compound);
analysis of the composition (of a substance/compound);
separation of mixtures; [2 max]
- (b) (O–S–O) bond angle changes;
(S–O) bond (length) stretches;
Allow [1] for S–O bond vibrations if neither of the above points are scored.
- polarity of SO₂ molecule changes; [3]
- (c) *Description should include:*
monochromator (to create single wavelength);
(rotating) mirrors/beam splitting;
sample and reference (to compare);
photomultiplier detector; [4]
Allow diagram to show this.
- (d) A is Spectrum I **and** B is Spectrum III **and** C is Spectrum II;
- A Spectrum I:*
only spectrum with a (broad) peak in the range 2500–3300 (cm⁻¹) corresponding to the carboxylic acid functional group / –OH in carboxylic acid / H-bonding in carboxylic acid (so must be a carboxylic acid);
- B Spectrum III:*
peak in the range 1700–1750 (cm⁻¹) corresponding to the carbonyl/C=O group;
but no peak for O–H/no peak at 2500–3300 (cm⁻¹) or 3200–3600 (cm⁻¹);
- C Spectrum II:*
peak in the range 3200–3600 (cm⁻¹) corresponding to the alcohol functional group/OH / the only one without a peak at 1700–1750 (cm⁻¹) corresponding to an alcohol; [5]
- A2.** (a) 2-bromopropane will show two separate absorptions/peaks;
in the ratio 6:1;
1-bromopropane will show three separate absorptions/peaks;
in the ratio 3:2:2; [4]
- (b) magnetic resonance imaging (MRI) gives a three-dimensional view of organs in the human body / *OWTTE*;
because protons in water molecules/lipids/carbohydrates in human cells give different signals, depending upon their environment / *OWTTE*; [2]

Option B — Human biochemistry

- B1.** (a) isoelectric point;
zwitterion/forms neutral ion when H^+ transfers from $COOH$ to NH_2 ;
buffer action/can accept H^+ and OH^- ;
general formula $HOCCRHNH_2$; [3 max]
- (b) (i) peptide/amide; [1]
- (ii) hydrogen bonds; [1]
- (iii) hydrogen bonds;
disulfide bridges/bonds;
ionic interactions/bonds;
van der Waals' forces / hydrophobic interactions / London/dispersion forces /
temporary induced dipoles; [2 max]

B2. (a)

correct structure of glycerol **and** correct formula of stearic acid;
correct structure of triglyceride;
 $3H_2O$ **and** coefficient of 3 on stearic acid; [3]
Accept displayed or condensed formulas for molecules.

- (b) (i) both have first double bond on C9 with carbon / linoleic has an $\omega - 6$ $C=C$ double bond and linolenic acid has an $\omega - 3$ $C=C$ double bond;
linoleic acid has 2 double carbon bonds **and** linolenic acid 3 double carbon bonds; [2]
- (ii) fatty acids are essential / body cannot synthesize them / *OWTTE*; [1]
- (c) (i) LDL is (a) larger (molecule) than HDL;
LDL transports cholesterol to arteries **and** HDL removes cholesterol from arteries;
LDL produced from saturated fats/trans fatty acids;
LDL increases the risk of heart disease/problems; [2 max]
Accept converse statements for HDL.
Do not accept LDL is bad cholesterol and HDL is good cholesterol.
- (ii) cholesterol is composed of C, H and O only and phospholipid contains C, H, O, P and N; [1]
- (iii) lecithin; [1]

- B3.** (a) alkene/ketone; **[1]**
Accept carbonyl.
Do not accept aldehyde.
- (b) change release of hormones/FHS/LH (from hypothalamus/pituitary gland);
prevent ovulation / egg release;
prevent attachment of egg to uterus / thin lining of the uterus/endometrium;
prevent sperm from reaching egg / thicken cervical mucus; **[2 max]**
Do not accept “mimic pregnancy”.

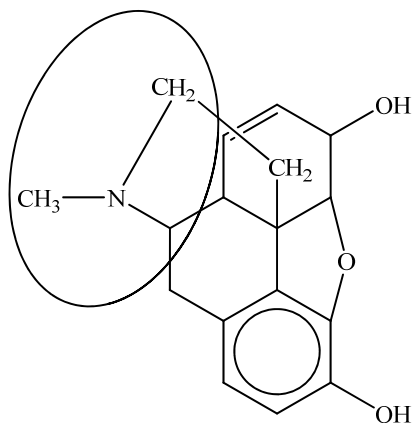
Option C — Chemistry in industry and technology

- C1.** (a) involves research and technology development at the 1 nm to 100 nm range / novel properties because of their small size / control or manipulate at the atomic scale / *OWTTE*; [1]
- (b) main cylinder is made only from carbon hexagons, with pentagons required to close the structure at the ends;
single or multiple walled tubes made from concentric nanotubes can be formed;
bundles of the tubes have high tensile strength;
other substances (elements, metal oxides etc.) can be inserted inside the tubes;
strong covalent bonding / no weak bonds;
behaviour of electrons depends on the length of a tube and hence some forms are conductors and some are semiconductors; [4 max]
- (c) hazards associated with small airborne particles are not known / long term effects unknown / *OWTTE*;
may not be covered by current toxicology regulations (as properties depend on the size of the particle) / may be toxic / *OWTTE*;
human immune system may be defenceless against new nanoscale products / *OWTTE*;
(there may be social problems) as poorer societies may suffer as established technologies become redundant and demands for commodities change / *OWTTE*; [4]
- C2.** (a) liquid crystals are fluids that exhibit orientation of the molecules/an orderly arrangement of molecules;
II, since there is one-dimensional order (characteristic of a liquid crystalline phase); [2]
- (b) *thermotropic liquid crystals* are pure substances that show liquid crystal behaviour over a temperature range (between the solid and liquid states);
example (of thermotropic liquid crystals) is biphenyl nitriles;
lyotropic liquid crystals are solutions that show the liquid crystal state at certain concentrations;
example (of lyotropic liquid crystals) is soap in water; [4]
Award marks for examples, only if they are associated with the correct class of liquid crystals.
- (c) chemically stable;
a liquid crystal phase stable over a suitable range of temperatures;
polar in order to change orientation when an electric field is applied;
rapid switching speed; [2 max]
- C3.** (a) neither cause pollution when running;
lead/sulfuric acid are pollutants (making or disposing of battery);
production of hydrogen and oxygen for fuel cells causes pollution; [2 max]
- (b) no, since the fuel must be fluid/liquid or gas / the fuel must be continuously supplied to the fuel cell/it must be able to flow; [1]

Option D — Medicines and drugs

- D1.** (a) aspirin useful in preventing the recurrence of heart attacks/strokes / prevents blood clots;
 aspirin reduces fever more effectively/antipyretic;
 anti-inflammatory;
 paracetamol overdose causes long term damage / easier to overdose on paracetamol / possible liver damage; [2 max]
- (b) mild analgesics function by intercepting the pain stimulus at the source / interfere with the production of substances that cause pain/prostaglandins;
 strong analgesics work by bonding to receptor sites in the brain / prevent the transmission of pain impulses without depressing the central nervous system; [2]

(c) (i)



any circle around the nitrogen atom / the nitrogen atom and its three neighboring atoms; [1]

(ii) tertiary; [1]

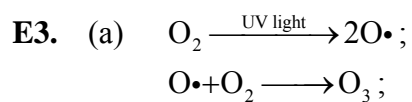
(iii) ester; [1]

- (d) *Advantage:* antidiarrheal/constipation (in treatment of diarrhea) / reduces coughing;
Disadvantage: addiction / tolerance / risk of overdose; [2]

- D2.** (a) alters incoming sensory sensations / alters mood or emotions; [1]
- (b) (i) the range over which a drug can be safely administered / $T.I = \frac{LD50}{ED50}$ / ratio of the lethal dose for 50% population and the effective dose for 50% of population; [1]
- (ii) person needs to take ever larger quantities of a drug to gain the original effect; [1]
- (iii) therapeutic effect of an inert substance on the body / body is fooled into healing itself naturally / *OWTTE*; [1]
- (c) drug is isolated from existing species / synthesized in the laboratory; tested on animals to establish LD50; tested on humans and half/some of the group is given a placebo; [3]
- D3.** (a) at moderate doses sedation/soothing/reduction of anxiety/impaired judgement; at higher doses induce sleep/unconsciousness / extremely high dose may cause death/organ failure; [2]
- (b) (i) orange to green; [1]
- (ii) reduced because oxidation number of Cr decreases / Cr gains electrons; *Explanation needed for mark.* [1]

Option E — Environmental chemistry

- E1.** (a) H₂O;
N₂O/nitrous oxide/dinitrogen monoxide/nitrogen(I) oxide;
chlorofluorocarbons/CFCs/e.g. CCl₂F₂;
O₃/ozone;
SF₆; **[2 max]**
Do not accept NO_x/nitrogen oxides.
Accept names or formulas.
- (b) *Gas:* H₂O **and reason:** greatest abundance;
Gas: CO₂ / H₂O **and reason:** greatest abundance;
Gas: CH₄ / N₂O **and reason:** more effective at absorbing radiation;
Gas: CFC / SF₆ more effective at absorbing radiation/very long life in atmosphere; **[2 max]**
- (c) thermal expansion of the oceans / changes in sea temperature affecting sea life;
melting of the polar ice-caps/glaciers / rising sea levels;
floods / droughts / changes in precipitation and temperature;
changes in migration patterns of animals / changes in distribution of species / species
more likely to become naturalized;
changes in the yield/distribution of crops;
changes in the distribution of pests/insects/pathogens/disease-carrying organisms; **[2 max]**
Do not accept "climate change".
- E2.** (a) amount of oxygen needed to decompose organic matter;
in a specified time/five days / at a specified temp/ 20 °C; **[2]**
Second mark can only be awarded if reasonable attempt made to define BOD.
- (b) (i) oxygen/gases less soluble in hot water; **[1]**
- (ii) fertilizer causes excessive algal growth so oxygen concentration
reduced/effects of eutrophication / *OWTTE*; **[1]**
Stating eutrophication alone is not sufficient.
- (c) (i) gained electrons; **[1]**
- (ii) +4 to +2 / decrease by 2; **[1]**
- (iii) 0.00005/5×10⁻⁵ (moles); **[1]**
- (d) the seawater is heated;
(then passes to) another container where the (surrounding) pressure is lower which
causes it to boil rapidly (as to flash into steam);
only a small portion converts to steam so the remaining water will be sent through (a
series of) additional stages each with a lower pressure; **[3]**



Do not penalize the omission of the radical symbol •

[2]

- (b) *advantages:* no weak C–Cl bond / not ozone depleting / do not release Cl atoms;
disadvantages: flammability / ability to absorb infrared radiation / increased greenhouse effect / contribute to global warming;

[2]

Option F — Food chemistry

- F1.** (a) (ability to) reflect and absorb different wavelengths/frequencies/colours of visible light; [1]
- (b) (i) anthocyanins; [1]
- (ii) form deeply coloured (coordination) complexes with Fe^{3+} and Al^{3+} /metal ions / discoloration/loss of colour and browning in canned fruit; [1]
- (c) (i) carotenoids; [1]
Do not accept β -carotene.
- (ii) presence of (multiple) carbon–carbon double bonds; loss/bleaching of colour / loss of vitamin A activity / off odours; [2]
Do not accept change of colour.
- F2.** (a) a substance that delays the onset or slows the rate of oxidation; [1]
- (b) vitamin C (ascorbic acid) **and** citrus fruits/green peppers/broccoli/green leafy vegetables/strawberries/raw cabbage/potatoes/other suitable source; vitamin E **and** wheat germ/nuts/seeds/whole grains/green leafy vegetables/vegetable oils; β -carotene **and** carrots/squash/broccoli/sweet potatoes/tomatoes/kale/cantaloupe melon/peaches/apricots; selenium **and** fish/shellfish/red meat/eggs/grains/chicken/garlic; polyphenols **and** grapes; [2 max]
- (c) fermentation; preserving/canning; pickling; salting; drying; smoking; cooling/refrigeration; reduced exposure to light; [2 max]
- (d) hydroxyl/phenol/alcohol; alkene/arene/benzene/phenyl; [2]
Accept names or formulas.
Do not accept alkyl groups as functional groups.
- (e) *advantages:*
vitamins C, E and carotenoids reduce the risk of cancer and heart disease / vitamin C produces hormones and collagen / vitamin C prevents scurvy / β -carotene can be used to give margarine colour;
- disadvantages:*
add colour and an aftertaste to food / less effective at slowing down the rate of rancidity/oxidation than synthetic antioxidants; [2]

- F3.** a genetically modified food is derived/produced from a genetically modified organism;
Award [1] for definition.

benefits:

crops: enhanced taste/quality/appearance;
reduced maturation time;
increase in nutrients and yield;
improved resistance to disease, pests and herbicides;
enrichment of rice with vitamin A;

animals: increased resistance;
productivity and feed efficiency;
better yields of milk/egg;
improved animal health;

environment: “friendly” bio-herbicides and bio-insecticides;
conservation of soil/water/energy;
improved natural waste management;

concerns:

(links to) increased allergies (for people involved in their processing);
altered composition of (balanced) diet / altered nutritional quality of food;
change in ecosystems / development of “superweeds”/“superbugs”;

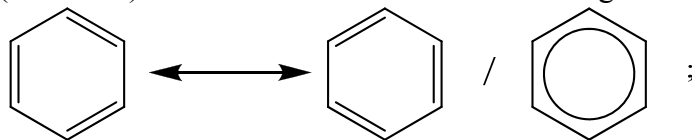
Award [4 max] for benefits and concerns.

To score [4] both benefits and concerns must appear in answer.

[5 max]

Option G — Further organic chemistry

- G1.** (a) contains a six-membered carbon ring;
 all C–C bond distances are equal/0.139 nm;
 C–C bond lengths are intermediate between single (0.154 nm) and double bonds (0.134 nm) / has delocalized electrons / drawing showing two resonance forms *e.g.*



planar;

all bond angles are 120°/the same;

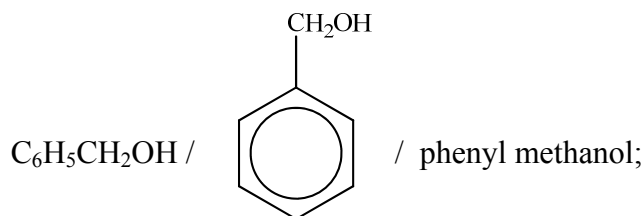
Accept all carbons are sp^2 hybridization.

[4 max]

- (b) $(\Delta H^\ominus =) -360 \text{ (kJ mol}^{-1}\text{)}$;

[1]

- (c) (i)



$S_N(2)$ /nucleophilic substitution (bimolecular);

[2]

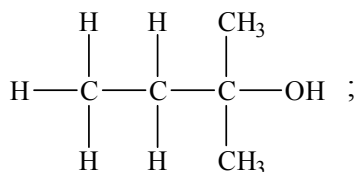
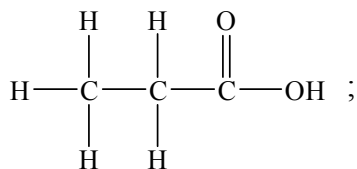
- (ii) OH^- ions repelled by the delocalized electrons in aromatic ring / *OWTTE*;
 C–Br bond is stronger/harder to break because lone pair of electrons on Br interact with delocalized electrons / *OWTTE*;

[2]

- G2.** (a) (i) CH_3MgBr /methyl magnesium bromide;

[1]

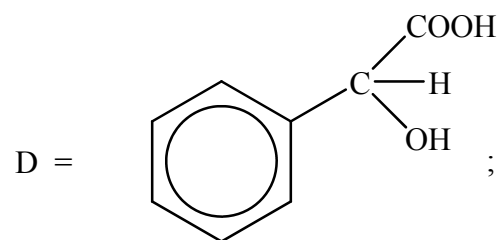
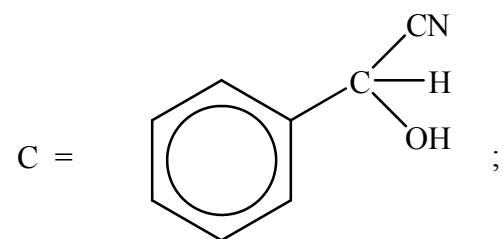
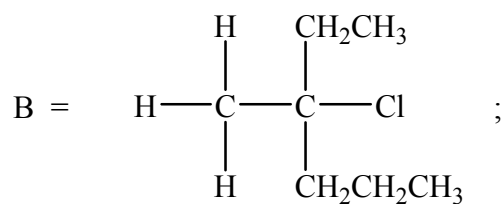
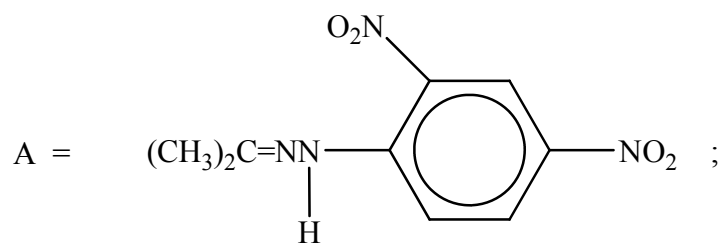
- (ii)



[2]

Allow correct condensed structural formula in each case *e.g.* CH_3CH_2COOH etc.

(b)

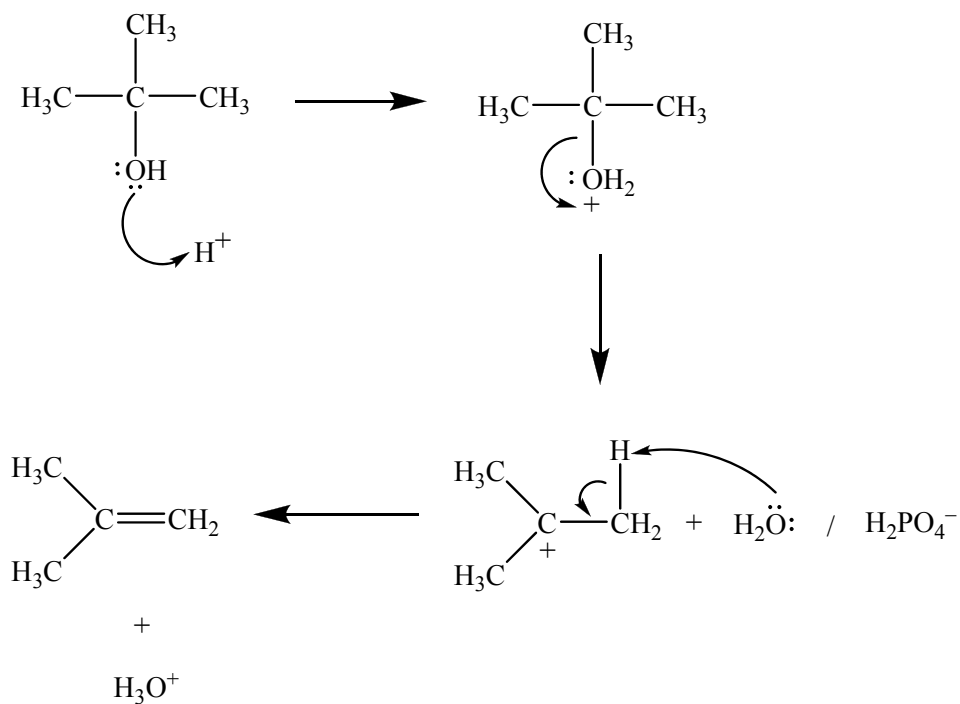


[4]

Allow correct condensed structural formula in each case.

Do not penalize students if they draw a structure that attaches NO₂ to benzene ring via O and not N, also students do not have to show double and triple bonds.

G3.



correct identification of products as $(\text{CH}_3)_2\text{C}=\text{CH}_2$ /methylpropene;

mechanism showing:

curly arrow going from (lone pair of electrons on) O to H^+ ;

structure of carbocation;

curly arrow from (lone pair on) oxygen of water to H shown;

Award [3] for a concerted mechanism.

Correct geometry is not required for structure of carbocation.

[4]