M11/4/CHEMI/SP3/ENG/TZ2/XX/M

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MARKSCHEME

May 2011

CHEMISTRY

Standard Level

Paper 3

17 pages

General Marking Instructions

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 <u>underlined</u> are essential for the mark.

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

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

8. 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.

9. Only consider units at the end of a calculation.

10. 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*

11. 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.

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

(b) *Microwave:*
(molecular) rotation;
Do not allow mark if incorrect rotations (i.e. not molecular) are stated.

Ultraviolet:
electronic transition; ***[2]***

(c) infrared/IR; ***[1]***

(d) IR involves vibrations of bonds / IR involves shorter wavelength/more energy than ^{1}H NMR;
whereas ^{1}H NMR involves transitions between different energy states in the nucleus which are lower in energy / ^{1}H NMR occurs in the radio region therefore energy is lower; ***[2]***

A2. (a) (stretches/vibrations in) HBr involve change in bond dipole / (stretches/vibrations in) Br_2 do not involve change in bond dipole; ***[1]***

(b) (i) ***I:*** O–H;

II: C–H;

III: C=O; ***[3]***
*Award **[2]** for C–H for **I** and O–H for **II**.*

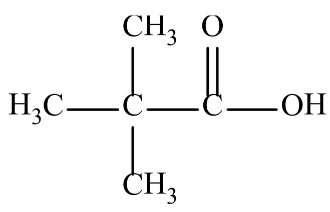
(ii) *m/z* = *102 :* molecular ion peak / $(CH_3)_3CCOOH^+$ / $C_5H_{10}O_2^+$ / M^+;

m/z = *57 :* $(CH_3)_3C^+$ / $(M-COOH)^+$ / $C_4H_9^+$;

m/z = *45 :* $COOH^+$; ***[3]***
Penalize missing + once only.

(iii) (H of) COOH group; ***[1]***

(iv) nine hydrogens in the same environment / $(CH_3)_3C-$ (group); ***[1]***

(v) $(CH_3)_3CCOOH$ / $(CH_3)_3CCO_2H$ /  ; ***[1]***

(vi) no peak at 11.5 ppm in spectrum of isomer / different chemical shift values;
four peaks (instead of two) / different number of peaks;
Three of these peaks can be split in actual spectrum, so allow for this in answers if exactly four peaks is not stated.

different integration trace / different areas under the peaks / integration trace would have a 3:2:2:3 peak area ratio; ***[2 max]***
Do not award mark if incorrect peak area ratios are given for the structure drawn in (v).

A3. human body consists of 70 %/mostly/a lot of water;
protons in water molecules/in carbohydrates, proteins and fats can be detected by MRI;
water in different environments;
organs have different water to lipid ratios;
so that protons have different environments so produce different effects; ***[2 max]***

Option B — Human biochemistry

B1. (a) **X** is glycerol/propane-1,2,3-triol/ $CH_2(OH)CH(OH)CH_2(OH)$;
Y is water/ H_2O; *[2]*

(b) $CH_2OOC(CH_2)_6CH_3$
$CHOOC(CH_2)_{10}CH_3$
$CH_2OOC(CH_2)_{16}CH_3$; *[1]*
Accept the fatty acids in any order.

(c) solid as contains (three) saturated/straight fatty acid chains;
can pack closer together;
have stronger London/dispersion/van der Waals' forces between chains; *[3]*

(d) esterification / condensation; *[1]*

(e) fats contain less oxygen than carbohydrates / are in a less oxidised state (so more energy is released); *[1]*

B2. (a) (i) organic dye / ninhydrin; *[1]*

(ii) glutamic acid/Glu;
isoelectric point is below pH of buffer / acts as an acid / loses H^+;
becomes negatively charged; *[3]*

(iii) balanced (positive and negative) charges / no overall charge / zwitterion;
amphoteric / buffer solution; *[1 max]*

(b) $H_2NCH_2COOH + H^+ \rightleftharpoons H_3N^+CH_2COOH$ / $H_3N^+CH_2COO^- + H^+ \rightleftharpoons H_3N^+CH_2COOH$;

$H_2NCH_2COOH + OH^- \rightleftharpoons H_2NCH_2COO^- + H_2O$ /
$H_3N^+CH_2COO^- + OH^- \rightleftharpoons H_2NCH_2COO^- + H_2O$; *[2]*
Accept $\rightarrow$ *instead of* $\rightleftharpoons$

B3. (a) required in very small amounts in human body / less than 0.005 % of body weight required;
Fe / Cu / F / Zn / I / Se / Mn / Mo / Cr / Co / B; *[2]*

(b) xerophthalmia / night blindness / dry eyes;
acne; *[1 max]*

(c) fat soluble as long non-polar/hydrocarbon chain;
with few polar groups;
cannot form hydrogen bonds with water; *[2 max]*

Option C — Chemistry in industry and technology

C1. (a) (i) melting point of the cryolite solution is much lower than the melting point of alumina/Al_2O_3 / it lowers the melting point of the mixture / cell operates at lower temperature; ***[1]***

Allow lowers melting point or lowers melting point of aluminium oxide.
Do not allow lowers melting point of aluminium.

(ii) *Positive electrode*:
$2O^{2-} \rightarrow O_2 + 4e^- \,/\, O^{2-} \rightarrow \frac{1}{2}O_2 + 2e^-$;

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

*Award **[1]** for correct equations but wrong electrodes.*
Allow e instead of e^-.

(b) use of fossil fuels (to provide energy);
oxidation of the (graphite) positive electrode/anode; ***[2]***

C2. (a) homogeneous catalysts are in the same phase/state as reactants **and** heterogeneous catalysts are in a different phase/state to reactants; ***[1]***

(b) (i) reactants are adsorbed onto the surface of the catalyst;
bonds are weakened so molecules are more likely to react / collisions with correct orientation occur more frequently; ***[2]***

(ii) only effective on the surface / get poisoned / forms clumps / efficiency/surface area decreases over time; ***[1]***

(c) should produce only the desired product / selectivity;
efficiency;
should be able to work under both mild and severe conditions / should be able to work at high temperatures;
should not produce an (unwanted) environmental impact;
cost / economic viability / *OWTTE*;
ease of poisoning/contamination; ***[2 max]***

(d) (i) (catalyst a mixture of) silica/silicon dioxide/SiO_2 **and** alumina/aluminium oxide/Al_2O_3 / zeolites/aluminosilicates;
high temperature / $500\ ^\circ C$; ***[2]***

(ii) $C_{15}H_{32} \rightarrow C_8H_{18} + C_7H_{14} \,/\, C_{15}H_{32} \rightarrow C_8H_{16} + C_7H_{16}$; ***[1]***

C3. (a) (rod-shaped) molecules aligned in the same direction;
increasing temperature causes arrangement to lose its directional order/molecules to become more randomly arranged;
until normal liquid state occurs; ***[3]***

(b) chemically stable so that it does not undergo reactions;
liquid-crystal phase stable over a range of temperatures so that frequent malfunctions do not occur;
molecules should be polar so the electronic current can influence direction;
there should be a rapid change in direction / fast switching speed; ***[3 max]***
Award [2 max] if no reasons are given.

Option D — Medicines and drugs

D1. (a) (i) *Advantage of aspirin*:
prevents (recurrence of) heart attack/stroke / anticoagulant / reduces fever/inflammation;

Disadvantage of paracetamol:
may cause blood disorders/kidney damage / (overdose can cause serious) liver damage/brain damage/death / does not reduce inflammation; ***[2]***
Do not accept increased toxicity when consumed with ethanol.

Do not accept the same argument for advantage of aspirin and disadvantage of paracetamol.
Do not accept answers which refer to disease (i.e. reduces heart disease, causes kidney disease) or cancer.
Penalize additional incorrect answers if more than one advantage or disadvantage is stated.

(ii) increased risk of stomach bleeding; ***[1]***

(b) (i) administered by injection; ***[1]***

(ii) (temporarily) bond to receptor sites in the brain/CNS;
prevent the transmission of pain impulses; ***[2]***

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

D2. (a) anxiety;
irritability/restlessness;
sleeplessness;
increased urine output/diuretic;
trembling/shaking;
increased heart rate/tachycardia; ***[2 max]***

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

(ii) (tertiary) amine; ***[1]***

(iii) increased heart rate / increased blood pressure / reduction in urine output / reduction in anxiety ***[1]***

D3. (a) if concentration is too high it will have harmful side effects / determination of the lethal dose (to 50 % of the population) / *OWTTE*;
if concentration is too low it has little or no beneficial effect / determination of the effective dose / dose which has a noticeable effect (on 50 % of the population) / *OWTTE*;
therapeutic window is the range between these doses / range over which a drug can be safely administered / ratio of $LD_{50} : ED_{50}$;
for minor ailments a larger window is desirable, for serious conditions a smaller window may be acceptable / *OWTTE*;
(therapeutic window) depends on the drug/age/sex/weight;
a small therapeutic window means that an overdose is a high risk / *OWTTE*; ***[4 max]***

(b) placebo contains none of the compound being tested as a drug;
placebo can "fool" the body into healing itself / *OWTTE*;
placebo is used as a control to measure the effectiveness of a drug / *OWTTE*;
half/some of trial group given placebo and half/some given drug;
patients and administrators should not know who gets a placebo and who gets a drug / double blind trial; ***[3 max]***

(c) LD_{50} / ED_{50};
risk:benefit ratio;
side-effects;
tolerance; ***[1 max]***

Option E — Environmental chemistry

E1. (a) N_2O ;
artificial fertilizers / combustion/decomposition of biomass;

*Award **[2 max]** for one of the following pairs.*
H_2O ;
evaporation of oceans/lakes;

OR

SF_6 ;
insulator in electrical industry;

OR

O_3 ;
photochemical smog / electrical generators; ***[4 max]***

Allow correct names (e.g. ozone) instead of formulas.
*Sources must match gases for **[1]**.*

(b) breakdown of grass in animals stomachs / microbes in animals stomachs / by-product of fermentative digestion in rumen (and hind gut); ***[1]***

(c) seasonal since plants grow in spring and decay in autumn/fall / amount of CO_2 in the atmosphere depends on (natural processes such as) photosynthesis, which happens (more) in spring and summer than in autumn/fall and winter; ***[1]***

(d) rise in sea levels / thermal expansions of the oceans;
melting polar ice-caps/glaciers;
changes in climatic patterns / *OWTTE*;
changes in agriculture and bio-distribution / *OWTTE*; ***[1 max]***
Allow specific changes.

E2. (a) $O_2 (+ \text{UV}/hf/hv) \rightarrow 2\text{O}\bullet$;
$O_2 + \text{O}\bullet \rightarrow O_3$; ***[2]***
Accept O instead of O•

(b) (i) refrigerants/refrigerators;
solvents;
foaming agents / blowing agents (in plastics);
aerosol containers / propellents; ***[2 max]***

(ii) *Advantage*:
CH bond stronger than CCl / *OWTTE*;
Allow hydrocarbons do not harm the ozone layer.

Disadvantage:
flammable / contribute to global warming / less efficient / greenhouse gases; ***[2]***

E3. (a) *Mercury:*
batteries / fungicides/seed dressings / electrolysis of brine/manufacture of chlorine/sodium hydroxide / dental amalgams / paints;
Allow pesticides.

PCBs:
capacitors / transformers / other electrical equipment / plasticizers / adhesive industries; ***[2]***

(b) *Multi-Stage Distillation*:
sea water is heated to its boiling point / water vaporizes;
condensation of pure water / water free of impurities;
heat given off by condensing water saves energy;

Reverse Osmosis:
high pressure / greater than osmotic pressure / 70 atm;
uses partially/semi-permeable membrane;
water passes through leaving salts behind;
high energy cost to achieve pressure needed / *OWTTE*; ***[5 max]***

Option F — Food chemistry

F1. (a) (i) (component) fatty acids;
glycerol/propane-1,2,3-triol/ $CH_2(OH)CH(OH)CH_2(OH)$; ***[2]***

(ii) (presence of) enzymes/lipase;
heat; ***[2]***

(iii) nitrogen excludes <u>oxygen</u>;
foil pack excludes light;
oxygen/light increases the rate of oxidation;
fatty acid chains are oxidized / oxygen adds across C=C double bond of unsaturated fatty acid / produces aldehydes and ketones; ***[3 max]***

(b) (emulsifiers are) molecules with long non-polar tail and a polar head / soluble in fat and water / contain polar and non-polar groups / contain hydrophilic and hydrophobic groups;
oil droplets are surrounded by tails of many emulsifier molecules;
(so that the) outside of the drops consist of polar heads;
polar heads mix with water molecules;
small oil droplets are unable to join together (and disperse through the liquid) / *OWTTE*; ***[3 max]***

F2. (a) (i) both contain phenol groups / many hydroxyl groups / aromatic rings / ester groups
only EGCG has an ether group / only rosmarinic acid has a carboxylic acid group / only rosmarinic acid has a C=C double bond / rosmarinic acid has 2 rings and EGCG has 4; ***[2]***

(ii) lower levels of LDL cholesterol;
lower blood sugar levels;
reduce high blood pressure;
prevent development of cancer; ***[2 max]***

(b) (i) quinoidal base $+ H^+ \rightleftharpoons$ flavylium cation / $QB + H^+ \rightleftharpoons FC^+$; ***[1]***
Accept $\rightarrow$ *instead of* $\rightleftharpoons$

(ii) blueberries are acidic **and** H^+ ions react with aluminium to form Al^{3+};
Al^{3+} ions form (deeply) coloured (coordination) complexes with anthocyanins;
fruit discoloured;
Al^{3+} cause health problems / Al^{3+} deposited in bones instead of Ca^{2+}; ***[2 max]***

F3. (a) food derived or produced from an animal or plant in which the DNA/genetic material has been altered by artificial means / *OWTTE*; ***[1]***
Do not accept that foods themselves have had genes inserted in them.

(b) *Benefit*:
reduced maturation time so increasing the number of crops grown in a season;
increased nutrients/enrichment of rice with vitamin A to reduce nutrient deficiencies;
increased yield so able to feed more people;
improved climate range so increasing the growing season;
improved resistance to disease/pests/herbicides so reducing the need for pesticides;
improved flavour;
incorporate beneficial substances;
increase shelf life; ***[1 max]***

Concern:
increased risk of allergies in people exposed to the crops during harvesting or food production;
risk of change to the composition of a balanced diet by altering the nutritional quality of food; ***[1 max]***
risk of harm to ecosystems if genetically modified crops mix with natural species;

*Award **[1 max]** if a list has been produced with no discussion.*

Option G — Further organic chemistry

G1. (a) 1,3-cyclohexadiene; ***[1]***

(b) addition reactions not favoured energetically since this would involve disruption of cloud of delocalized electrons / stabilization energy would need to be supplied and product would lack delocalized ring of electrons making it less stable / *OWTTE*; ***[1]***

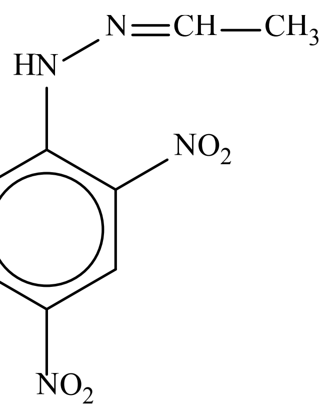
(c) *For chloromethylbenzene*:
electron deficient carbon on $–CH_2Cl$ group making it susceptible to nucleophilic attack;

For chlorobenzene:
steric hinderance / repulsion by electron cloud in benzene ring/C–Cl less polar;
C–Cl bond stronger; ***[2 max]***
*Award **[1]** mark for either of the above.*

G2. (a) (i) $H_3CCHClCH_2I$; ***[1]***

(ii) $H_3CC(OH)(CN)H$; ***[1]***

(iii)



; ***[1]***

(iv) $(CH_3)_2CHOH$; ***[1]***

(b) CH_3CHICH_2Cl ; ***[1]***

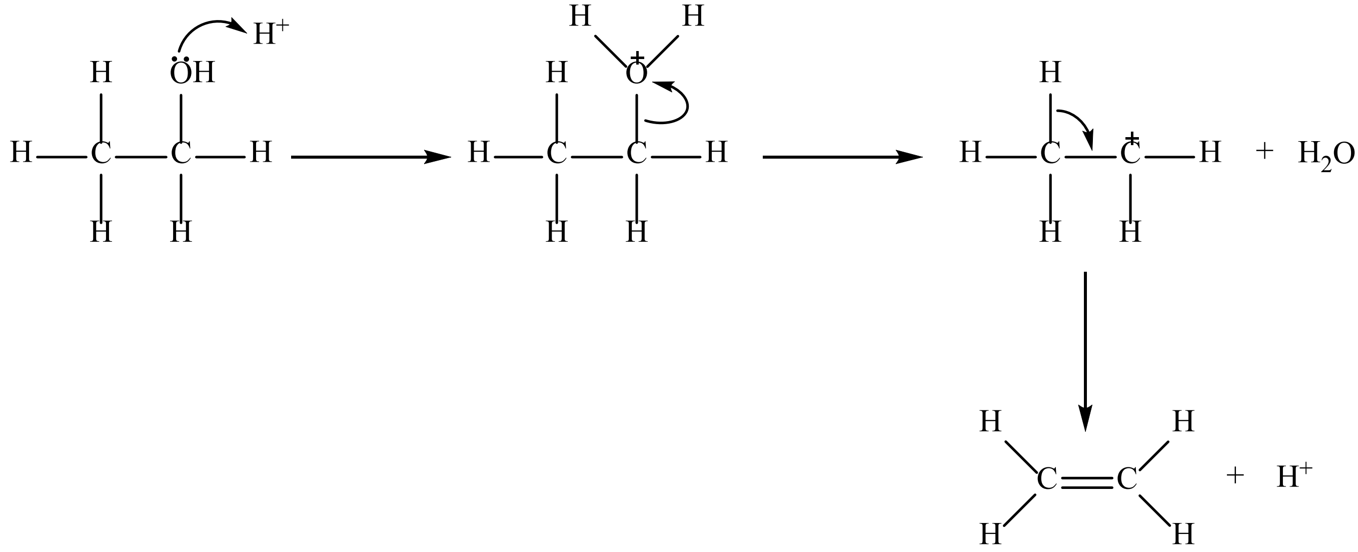
(c)

Reaction	Type
(a) (i)	electrophilic addition;
(a) (ii)	nucleophilic addition;
(a) (iii)	addition-elimination;
(a) (iv)	Grignard;

[4]

G3. *Catalyst*:
(concentrated) H_3PO_4/phosphoric acid / H_2SO_4/sulfuric acid;

Mechanism:



curly arrow going from O of OH to H^+ (showing protonation of OH group) **and** loss of water showing formation of carbocation;
curly arrow from CH of beta-carbon to CC;

Organic product:
ethene; ***[4]***
Accept ethylene.

G4. *Step 1:*
H_3PO_4/phosphoric acid / H_2SO_4/sulfuric acid;

Product from step 1:
$CH_3CH_2CH{=}CH_2$/but-1-ene;

Step 2:
Br_2/bromine; ***[3]***