M11/4/CHEMI/SP3/ENG/TZ1/XX/M

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MARKSCHEME

May 2011

CHEMISTRY

Standard Level

Paper 3

18 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) identification/detection/concentrations of metal/metal ions; ***[1]***

(b) ***X*** *– Name:*
monochromatic light source;
X *– Function:*
produces radiation/light of the same frequency/wavelength as is absorbed by the species (being detected);

Y *– Name:*
atomizer;
Y *– Function:*
converts liquid sample into small droplets / converts metal ions into atoms;

Z *– Name:*
monochromatic detector;
Z *– Function:*
detects radiation/light of the same frequency/wavelength absorbed / converts photons into electric current/signal; ***[6]***

If ***X*** *and* ***Z*** *correct except that "monochromatic" missed both times, penalize once only.*

A2. (a) *Compound:*
CH_3–CH_2–CHO;

Explanation: ***[1 max]***
only this compound would give 3 peaks / *OWTTE*;
only this compound has H–atoms in 3 different chemical environments / *OWTTE*;
only this compound has protons in ratio 3:2:1 in each environment / *OWTTE*
only this compound would give a peak in the 9.4–10 ppm region / *OWTTE*; ***[2 max]***

(b) 2.5 ppm peak;
CH_3–CO–CH_3 also has hydrogen atoms on a carbon next to the >C=O group; ***[2]***

(c) (i) 1700–1750 cm^{-1} (>C=O); ***[1]***

(ii) 1610–1680 cm^{-1} (>C=C<) / 3200–3600 cm^{-1} (–O–H); ***[1]***

(d) $C_3H_6O^+$ **and** m/z = 58;
$C_2H_5^+$ **and** m/z = 29;
CHO^+ **and** m/z = 29;
CH_3^+ **and** m/z = 15; ***[2 max]***
Penalize missing + sign once only.

A3. (a) two; ***[1]***

(b) silica/silicon dioxide/SiO_2;
alumina/aluminium oxide/Al_2O_3; ***[1 max]***
Accept either of the above.

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

(d) the ratio between the distance moved by the spot and the distance moved by the solvent front / *OWTTE*; ***[1]***
Accept this expressed as a correct equation.

(e) a spot drawn with its centre 1.4 cm from the start line; ***[1]***
Accept in the range 1.3 to 1.5 cm from the start line.

Option B — Human biochemistry

B1. (a) amylose **and** amylopectin;
(amylose) straight chain **and** (amylopectin) branched chain;
(amylose) (α-)1,4 linkages **and** (amylopectin) (α-)1,4 **and** (α-)1,6 linkages / (amylopectin) has (α-)1,6 linkages and amylose doesn't; ***[3]***

(b) both are polymers of glucose;
starch has α-1,4 (and α-1,6) linkages / bonds / α glucose;
cellulose has β-1,4 linkages / bonds / β glucose; ***[3]***

(c) absence of <u>cellulase</u> enzyme (in humans); ***[1]***

B2. (a) linoleic has 2 C=C / double bonds **and** linolenic has 3 C=C / double bonds;
linolenic acid (will have higher iodine value); ***[2]***
Accept linoleic has 3 double bonds and linolenic has 4 double bonds.

(b) essential fatty acids / cannot be synthesized in body;
lowers LDL cholesterol level / lowers risk of heart disease / affects inflammation / conversion to important molecules; ***[2]***

(c) A: $CH_3(CH_2)_{16}COOH$;
B: $CH_2OHCHOHCH_2OH$; ***[2]***
*Accept **[1 max]** if A and B reversed.*
Accept full structural formula.
Penalize missing H atoms once only.

(d) higher (melting point);
saturated fatty acids / no unsaturation / no C=C bonds; ***[2]***
Accept appropriate reason such as close packing, no kink in molecule, stronger van der Waals' forces, larger surface area of contact.
Accept opposite reasons why oleic acid would have a lower mp.

B3. (a) prevent release of hormones/FSH/LH (from hypothalamus/pituitary gland);
prevent/suppress ovulation/egg release;
prevent attachment of egg to uterus;
prevent sperm from reaching egg / thickens the cervical mucus;
mimics the action of progesterone during pregnancy / fools the reproductive system that the body is pregnant; ***[3 max]***

(b) recovery from injury/surgery/starvation/illness/disease;
increase in muscle mass / enhances performance/strength; ***[2]***

Option C — Chemistry in industry and technology

C1. (a) (i) a scale of 1–100nm;
careful positioning of individual atoms / ability to control/manipulate at atomic scale / production of material with novel properties; ***[2]***

(ii) health concerns / toxicity / effects on the human immune system / the lack of public involvement in policy discussions; ***[1]***

(b) in the walls carbon atoms only form hexagons;
in the ends the carbon atoms form both hexagons and pentagons; ***[2]***

C2. (a) *Catalytic cracking:*
used to produce moderate length alkanes (for fuels) / lower temperature / lower energy consumption / more control of product;

Thermal cracking:
used to crack very long chain starting material;

Steam cracking:
used to produce low molar mass alkenes (for petrochemicals); ***[3]***

(b) (i) heterogeneous catalysts in a different phase to the reactants / homogeneous catalysts in the same phase as reactants; ***[1]***

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

(c) <u>carbon-carbon</u> double bond;
breaks allowing addition reaction / allows monomers/molecules to join together/polymerize; ***[2]***

(d) make the polymer more flexible;
fits between/increases separation between polymer chains / allow polymer chains to slide past each other more easily / weaken intermolecular attraction; ***[2]***

C3. (a) oxygen blown through/over molten iron;
removes/oxidizes impurities;
alloying materials added (to produce steel required); ***[3]***

(b) *Award **[2 max]** for one of the following pairs:*
annealing – heat to a high temperature **and** slowly cooled;
makes the steel more malleable / more ductile / less brittle;

OR

quenching – heat to a high temperature **and** rapidly cooled;
makes the steel harder / more brittle;

OR

tempering – heat and keep at that temperature for some time;
makes the steel more malleable / more ductile / less brittle; ***[2 max]***

(c) waste rock from mining / airborne ash from blast furnace / the mine destroys the (natural) environment / uses energy resources / acid rain / carbon dioxide / greenhouse gas emissions; ***[1]***

Option D — Medicines and drugs

D1. (a) amide; ***[1]***
Do not accept carbonyl/ketone.

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

(c) anxiety
irritability/restlessness
sleeplessness/insomnia
increase in urine output/diuretic
trembling/shaking
increased heart rate / tachycardia ***[1]***
*Award **[1]** for any **two** symptoms.*

(d) *Short-term:*
increased heart rate
increased blood pressure / vasoconstriction
decrease in urine output
stress relief
*Award **[1]** for any **two** short-term effects.*

Long-term:
(increased risk of) heart disease/coronary thrombosis
(risk of) becoming addicted/physically dependent
(increased risk of) (lung/mouth/throat) cancer
(increased risk of) bronchitis/emphysema
reduction in capacity of blood to carry oxygen
withdrawal symptoms/weight gain (on quitting) ***[2 max]***
*Award **[1]** for any **two** long-term effects.*
*Award **[1 max]** if student has one long term and one short term correct.*

(e) (i) (sympathomimetic drug) mimics the effect of adrenaline / stimulates the sympathetic nervous system; ***[1]***

(ii) amphetamine / methamphetamine / speed / ecstasy / cocaine; ***[1]***

(f) ethanol can interact with / enhance the effect of other drugs;
with aspirin increased bleeding of the stomach lining/peptic ulcers **or**
other suitable example and their effect, such as sedatives, tranquilisers; ***[2]***

D2. (a) $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$ / $Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$; ***[1]***

Accept ionic equations.

(b) less effective **and** (magnesium hydroxide) 2/0.2 mol OH^- ions available as compared to (aluminium hydroxide) 3/0.3 mol OH^- ions for neutralization / neutralizes $2H^+$/0.2 mol acid as compared to $3H^+$/0.3 mol acid; ***[1]***

Do not accept aluminium hydroxide can neutralize more acid.

(c) strong base / corrosive / harmful to the body; ***[1]***

(d) *Alginates:*

provide a neutralizing layer on top of the stomach contents / to prevent acid rising up the esophagus / prevents acid reflux/heartburn;

Dimethicone:

as an anti-foaming agent / to prevent flatulence/gas/bloating; ***[2]***

D3. (a) viruses do not have cell/cellular structure;

viruses do not have nucleus;

viruses do not have cell wall;

viruses do not have cytoplasm; ***[2 max]***

Accept opposite statements for bacteria.

(b) stops virus replication;

Accept reproduction / multiplication.

becomes part of DNA of virus / alters virus DNA / blocks polymerase which builds DNA;

changes the cell membrane that inhibits the entry of virus into the cells;

prevents viruses from leaving the cell (after reproducing); ***[2 max]***

(c) HIV mutates (rapidly);

Accept AIDS mutates

HIV metabolism linked to that of host cell / HIV uses host cell / drugs harm host cell as well as HIV / difficult to target HIV without damaging host cell;

HIV destroys helper cells of the immune system; ***[2 max]***

Option E — Environmental chemistry

E1. (a) $CO_2 + H_2O \rightleftharpoons H_2CO_3$ / $CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$; ***[1]***

Do not penalize absence of reversible sign.

Do not accept $CO_2 + H_2O \rightarrow 2H^+ + CO_3^{2-}$.

(b) (i) *Acid 1:*

(HNO_2/HNO_3) high temperature in internal combustion/jet engine;

reaction between N_2 and O_2 at high temperature/lightning;

Accept either of the above for first mark.

$2NO_2 + H_2O \rightarrow HNO_3 + HNO_2$ / $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$;

Acid 2:

(H_2SO_3/H_2SO_4) from burning of coal / smelting plants / sulfuric acid plants / volcanic activity;

Do not accept combustion of fossil fuels.

$SO_2 + H_2O \rightarrow H_2SO_3$ / $SO_3 + H_2O \rightarrow H_2SO_4$; ***[4 max]***

Allow H_2SO_3/H_2SO_4 to be Acid 1 and HNO_2/HNO_3 to be Acid 2.

(ii) $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$; ***[1]***

Accept equation with H_2SO_3 or H_2SO_4 or ionic equations.

Do not accept equations with H_2CO_3.

E2. (a)

Element	Aerobic decomposition	Anaerobic decomposition
Carbon	CO_2/carbon dioxide	CH_4/methane
Nitrogen	NO_3^-/nitrate	NH_3/R–NH_2/ammonia /amines
Sulfur	SO_4^{2-}/sulfate	H_2S/hydrogen sulfide
Phosphorus	PO_4^{3-}/phosphate	PH_3/phosphine

*8 correct, award **[4]***
*6,7 correct, award **[3]***
*4,5 correct, award **[2]***
*2,3 correct, award **[1]***
*1 correct, award **[0]*** ***[4]***

(b) 162 g of $C_6H_{10}O_5$ requires 192 g of O_2;
0.010 g requires 0.012 g of O_2;

OR

n(organic matter) = $\frac{0.010}{162}$ **and** $n(O_2) = 6 \times n(\text{organic matter})$;
$m(O_2) = 6n(\text{organic matter}) \times 32.0 = 0.012\text{g}$; ***[2]***
*Award **[2]** for correct final answer.*

E3. high pressure / greater than osmotic pressure / 70 atm;
uses partially/semi permeable membrane;
drinking /pure water passes through;
salt/dissolved solids left behind;

OR

seawater is heated (under reduced pressure);
water is boiled;
water vapour is condensed;
salt/dissolved solids left behind; ***[3 max]***
Do not accept vapourized or evaporated instead of boiled.

E4. (a) incomplete combustion / air/fuel ratio is low; ***[1]***

(b) $2CO + 2NO \rightarrow 2CO_2 + N_2$ ***[2]***
*Award **[1]** for correct reactants and products and **[1]** for balancing.*
Do not apply ECF.

(c) greenhouse gas/effect; ***[1]***

(d) thermal exhaust reactor **and** lean burn engines; ***[1]***

Do not accept catalytic converter.

Option F — Food chemistry

F1. (a) *saturated:* Tallow;
mono-unsaturated: Olive oil;
poly-unsaturated: Linseed oil; ***[2 max]***
*3 correct award **[2]**, 2 correct award **[1]**, no marks for just one correct.*

(b) (i) the time that a food can be stored without the flavour/smell/colour/texture/appearance becoming unacceptable (to the consumer);
linseed; ***[2]***

(ii) reduce temperature;
store in dark;
remove oxygen / vacuum pack / replace air with inert gas;
reduce water content / drying;
add salt / sodium nitrite;
pickle;
add antioxidants;
genetic modification; ***[2 max]***
*Do **not** accept "add preservatives".*

(c) metal catalyst / Ni, Cu, Zn, Pd, Pt;
high temperature/pressure; ***[2]***

(d) fats with trans configuration across the double bond;
not easily digested / accumulate in body tissue / increase LDL cholesterol levels; ***[2]***
Do not accept "bad cholesterol".

F2. (a) (i) a dye is a synthetic colouring substance **and** pigments occur naturally; ***[1]***

(ii) the dye/pigment absorbs some colours/wavelengths/frequencies of light (whilst reflecting others); ***[1]***

(b) *An anthocyanin:*
beetroot / red cabbage / blackcurrants / cherries / red grapes / named berries;
Accept any other correct answer, but must have specific names e.g. strawberries instead of berries.

A carotene:
tomato / pumpkin / capsicum / bananas / squash / mango; ***[2]***
Accept any other correct answer but do not accept carrot.

(c) chlorophyll / hemoglobin / heme / myoglobin; ***[1]***

(d) labelling/safety regulations vary (considerably) between countries / a food produced in a country may be considered toxic in another / a toxic compound may not be banned in all countries / *OWTTE*; ***[1]***

F3. (a) a food from an animal or plant in which the DNA/genetic material has been altered by artificial means / *OWTTE*; ***[1]***

(b) *advantages* ***[2 max]****:*
quicker growth / reduced maturation time / more harvest per year;
increase resistance to disease/pests / less herbicides/pesticides / improved plant/animal health;
more tolerant of climate/extending its range / lower water consumption;
increase in the yield/productivity/feed efficiency;
improve flavour;
incorporate beneficial substances;
increased shelf life;

concerns ***[1 max]****:*
increase the risk of allergies;
affect the balance of people's diets;
escape of modified genes into the environment;
potential harm to natural ecosystem; ***[3 max]***

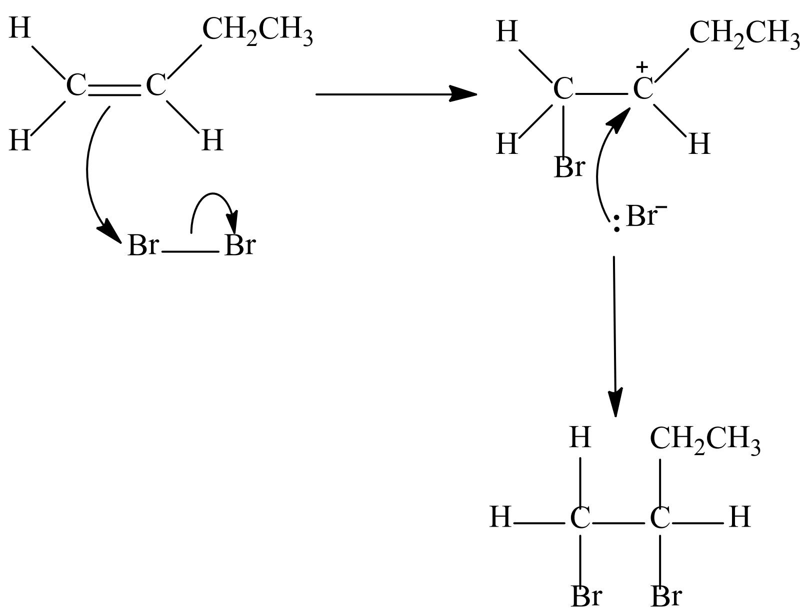
Option G — Further organic chemistry

G1. (a) but-1-ene;
Allow 1-butene.

$CH_3–CH_2–CH=CH_2$; ***[2]***

(b) $C_2H_5–CH(OH)–CH_3 \rightarrow C_2H_5–CH=CH_2 + H_2O$;
heat **and** (concentrated) phosphoric acid/H_3PO_4/sulfuric acid/H_2SO_4; ***[2]***

(c)



curly arrow going from C=C to Br of Br_2 **and** curly arrow showing Br atom leaving Br_2 molecule;
representation of carbocation;
curly arrow going from lone pair/negative charge on Br^- to C^+; ***[3]***

(d) butan-1-ol gives higher yield / butan-2-ol gives lower yield;
butan-2-ol will give but-2-ene as well as but-1-ene / butan-1-ol will only give but-1-ene; ***[2]***

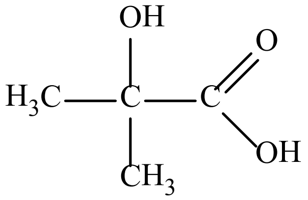
G2. (a) chlorobutane more rapid;

steric hindrance/repulsion by electron cloud from benzene ring in chlorobenzene;
C–Cl bond less polar/charge on C–Cl carbon smaller (owing to polarization of delocalized electrons);
C–Cl bond stronger (owing to partial π-bonding by lone pair); ***[3 max]***
Any 2 of the above for second and third marks.
Accept opposite statements for chlorobutane.
No ECF for second and third marks.

(b) $(CH_3)_2CH–Mg–Cl$;
anhydrous / absence of water / ether solvent; ***[2]***

(c) (i) propanone/$CH_3–CO–CH_3$ **and** hydrogen cyanide/HCN/cyanide ion/CN^-; ***[1]***

(ii)



/ $HO–C(CH_3)_2–COOH$;

[1]

G3. (a) amine salt;
$[(CH_3)_2NH_2]^+ + OH^- \rightarrow (CH_3)_2NH + H_2O$ /
$[(CH_3)_2NH_2]Br + OH^- \rightarrow (CH_3)_2NH + Br^- + H_2O$ /
$[(CH_3)_2NH_2]^+ + NaOH \rightarrow (CH_3)_2NH + Na^+ + H_2O$ /
$[(CH_3)_2NH_2]Br + NaOH \rightarrow (CH_3)_2NH + NaBr + H_2O$;

[2]

(b) greater / more alkaline;

the inductive/e^- donating effect of the methyl groups reduces the charge on the nitrogen atom of the cation / stabilizes the cation / *OWTTE*;

OR

the inductive/e^- donating effect of the methyl groups increases the negative charge on the nitrogen of the amine so that it attracts H^+ ions more strongly / *OWTTE*; ***[2]***