M12/4/CHEMI/HP3/ENG/TZ1/XX/M

International Baccalaureate®
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MARKSCHEME

May 2012

CHEMISTRY

Higher Level

Paper 3

20 pages

General Marking Instructions

Assistant Examiners (AEs) will be contacted by their team leader (TL) through Scoris™, by e-mail or telephone – if through Scoris™ or by e-mail, please reply to confirm that you have downloaded the markscheme from IBIS. The purpose of this initial contact is to allow AEs to raise any queries they have regarding the markscheme and its interpretation. AEs should contact their team leader through Scoris™ or by e-mail at any time if they have any problems/queries regarding marking. For any queries regarding the use of Scoris™, please contact emarking@ibo.org.

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1. Follow the markscheme provided, award only whole marks and mark only in **RED**.

2. Make sure that the question you are about to mark is highlighted in the mark panel on the right-hand side of the screen.

3. Where a mark is awarded, a tick/check (✓) **must** be placed in the text at the **precise point** where it becomes clear that the candidate deserves the mark. **One tick to be shown for each mark awarded.**

4. Sometimes, careful consideration is required to decide whether or not to award a mark. In these cases use Scoris™ annotations to support your decision. You are encouraged to write comments where it helps clarity, especially for re-marking purposes. Use a text box for these additional comments. It should be remembered that the script may be returned to the candidate.

5. Personal codes/notations are unacceptable.

6. Where an answer to a part question is worth no marks but the candidate has attempted the part question, enter a zero in the mark panel on the right-hand side of the screen. Where an answer to a part question is worth no marks because the candidate has not attempted the part question, enter an "NR" in the mark panel on the right-hand side of the screen.

7. If a candidate has attempted more than the required number of options within a paper or section of a paper, mark all the answers. Scoris™ will only award the highest mark or marks in line with the rubric.

8. Ensure that you have viewed **every** page including any additional sheets. Please ensure that you stamp 'seen' on any additional sheet that contains no other annotation.

9. Mark positively. Give candidates credit for what they have achieved and for what they have got correct, rather than penalizing them for what they have got wrong. However, a mark should not be awarded where there is contradiction within an answer. Make a comment to this effect using a text box or the "CON" stamp.

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.

2. Each marking point has a separate line and the end is shown 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 ***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. When marking, indicate this by adding **ECF** (error carried forward) on the script.

10. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the markscheme.

11. If a question specifically asks for the name of a substance, do not award a mark for a correct formula unless directed otherwise in the mark scheme, similarly, if the formula is specifically asked for, unless directed otherwise in the mark scheme 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) mass spectrometry/spectroscopy / MS; ***[1]***

(b) (i) ***A:*** O–H/hydroxyl;
B: C=C/carbon-carbon double bond; ***[2]***

(ii) no C=O/carbonyl present; ***[1]***

(c) (i) protons/H's in three different chemical environments / *OWTTE*;
2:1:1 ratio of protons/H's (in these environments) / *OWTTE*; ***[2]***
Accept 4:2:2.

(ii) $HO–CH_2–CH=CH–CH_2–OH$ / $CH_2=C(CH_2OH)_2$;; ***[2]***

(d) tetramethylsilane/TMS;

Any of these for second mark:
strong single peak (as there are 12 protons in identical chemical environment);
absorbs upfield/away from most other protons/H's;
low boiling point/bp / volatile (so easily removed from sample);
not toxic / unreactive / does not interfere with sample; ***[2 max]***

A2. (a) concentration of solution = 3.3 ($\mu g\ cm^{-3}$);
Accept any value in range 3.2 to 3.4.

concentration of metal in sample = $\left(\frac{0.200}{100}\times 10^6 =\right) 2000\ (\mu g\ cm^{-3})$ / 100 cm^3 of the solution contains 3.3×10^{-4} g of Mg $(3.3\times10^{-6}\times100)$;

percentage Mg in solution = 0.165 % $\left(=\frac{3.3}{2000}\times100 \text{ or } =\frac{100\times3.3\times10^{-4}}{0.200}\right)$; ***[3]***

Accept any value in range 0.16 to 0.17 %.
Accept other valid methods for calculation.

(b) different (monochromatic, hollow cathode) lamp/light source must be fitted; ***[1]***

A3. (a) place a spot of the liquid on a thin-layer chromatography/TLC plate;
place plate in a suitable solvent/eluent;
wait until solvent/eluent has almost reached the top of the plate;
spray/immerse plate in concentrated sulfuric acid/H_2SO_4/reagent to show spots / *OWTTE*;
*Do **not** accept ninhydrin.*

observe the plate to see how many spots are there on it; ***[3 max]***

(b) put spots of the pure sugars on the same plate as the mixture / produce chromatograms of the pure sugars under the same conditions as the mixture;
see if the spots in the mixture have moved the same distance/have same R_f as the pure sugars; ***[2]***

(c) (i) injected / introduced / enters column; ***[1]***

(ii) glucose attracted more strongly (than fructose) to mobile phase / fructose attracted more strongly (than glucose) to stationary phase; ***[1]***
Accept equivalent correct statements phrased in terms of "less strongly".

A4. (a) (i) contains double bonds/C=C/C=O; ***[1]***

(ii) <u>electron</u> transition from lower energy level to higher energy level; ***[1]***
Accept <u>electron</u> excited/promoted/absorbs energy.
Accept <u>electron</u> moves from bonding/π to antibonding/π^* orbital.

(b) **Z** absorbs at shorter wavelength/higher frequency/higher energy / **Y** absorbs at longer wavelength/lower frequency/lower energy;
double bonds in **Z** not conjugated / double bonds in **Y** conjugated / electrons not delocalized in **Z** / electrons delocalized in **Y**; ***[2]***

Option B — Human biochemistry

B1. (a) glycogen; ***[1]***

(b) *Name:*
steroids;

Role:
(sex) hormones;

OR

Name:
phospholipids;

Role:
membranes; ***[2 max]***

(c) lipids less oxidized/contain less oxygen / carbohydrates partially/more oxidized/contain more oxygen / *OWTTE*; ***[1]***

(d) *Enzyme:* hemoglobin **and** *Metal:* iron;
Role: (hemoglobin) carries oxygen (from lungs to cells);

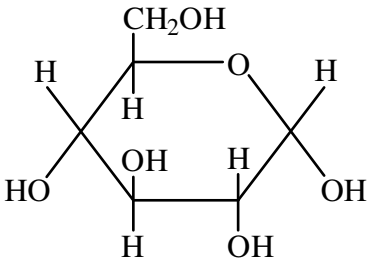
Enzyme: cytochrome(s) **and** *Metal:* copper;
Role: (cytochromes) catalyse redox reactions/electron transport (reactions involving ATP); ***[4]***

(e) lactate ion / lactic acid; ***[1]***

(f) *Any three for first three marks:*
both increase rate of chemical reactions;
both reduce activation energy;
both provide alternative pathways for reaction;
enzymes more specific;
enzymes have active site that substrate bonds to / "lock and key" mechanism;
enzymes much more readily denatured by changing conditions;

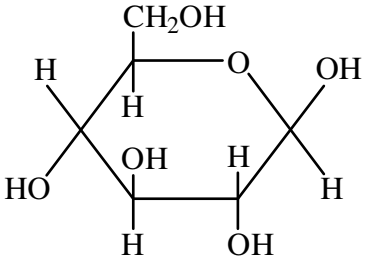
Both required for final two marks:
competitive inhibitors **and** non-competitive inhibitors;
competitive inhibitors bond to active site **and** non-competitive inhibitors denature/alter shape of enzyme; ***[5 max]***

B2. (a) α: C-1 OH below plane



;

β: C-1 OH above plane



; ***[2]***

(b) (i) aldehyde/alkanal/CHO; ***[1]***

(ii) ketone/alkanone/CO; ***[1]***

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

(c) cellulose is (condensation) polymer of β-glucose;
(rings in cellulose) joined by β-1,4 linkages; ***[2]***

B3. (a) micronutrients required in much smaller quantities/very small amounts/less than 0.005 % of body mass; ***[1]***
Accept opposite statement for macronutrients.

(b) beriberi / weight loss / fatigue; ***[1]***

(c) provide a naturally vitamin rich diet;
adding vitamins to common foods / fortification of staple foods;
genetically modifying foods (to increase vitamin content);
providing vitamin tablets / nutritional supplements; ***[2 max]***

Option C — Chemistry in industry and technology

C1. (a) *Name:* steel **and** *other element:* carbon; ***[1]***

(b) atoms/ions of the alloying element are a different size/larger/smaller;
prevents the layers of atoms/ions sliding across each other; ***[2]***

C2. (a) *Similarity:*
both turn chemical energy into electrical energy / use chemical reactions to produce electricity/electrical energy / *OWTTE*;

*Difference **[1 max]**:*
rechargeable batteries have reversible reactions **but** fuel cells do not;
fuel cells consume fuel **but** rechargeable batteries do not require (external) fuel;
rechargeable batteries can be recharged by electricity **but** fuel cells cannot; ***[2 max]***

(b)

	Positive terminal (when delivering a current)	Negative terminal (when delivering a current)
Initial oxidation number	+3	0
Final oxidation number	+2	+2
Anode / cathode	cathode	anode

*All correct **[3]**, 4 or 5 correct **[2]**, 2 or 3 correct **[1]*** ***[3]***

(c) *Positive electrode:*
$O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$;

Negative electrode:
$H_2(g) \rightarrow 2H^+(aq) + 2e^-$; ***[2]***

(d) large surface area;
changes only occur on the surface / where electron transfer occurs / *OWTTE*; ***[2]***

C3. (a) *Addition:*
double bond converted to single bond forming new bonds to other monomers / *OWTTE*;
poly(e)thene / polyprop(yl)ene / PVC / polystyrene / Teflon/PTFE;
Accept suitable diagram.

Condensation:
monomer contains two functional groups;
small molecule/water produced when monomers join together / *OWTTE*;
polyester/Terylene/Dacron / nylon/polyamide/Kevlar; ***[5]***
Accept suitable diagram.

(b) *Softening polymer:*
poly(e)thene / polypropylene / PVC / PET / polystyrene / Teflon/PTFE / polyester/Terylene/Dacron / nylon/polyamide;

Non-softening polymer:
phenol-urea/Bakelite / phenol-methanal/formaldehyde/Melamine;

Explanation:
rigid polymers have cross-links between polymer chains / polymers that soften do not have cross-links between polymer chains; ***[3]***

C4. (a) long rigid/rod-shaped molecules;
polar molecules / align with same orientation; ***[2]***

(b) chemically stable;
liquid crystal phase over a suitable range of temperatures;
rapid switching speed; ***[2 max]***

(c) (solution that only displays a liquid crystal state) over a range of/at certain concentrations; ***[1]***

Option D — Medicines and drugs

D1. (a) infrared/IR; ***[1]***

(b) diazepam/Valium® **and** nitrazepam/Mogadon®; ***[1]***
® *not necessary for mark.*

(c) salt has ions/ionic bonding;
forms polar/ion-dipole bonds/interactions with water / *OWTTE*; ***[2]***

(d) *Advantage*:
easily taken/convenient / no specialist equipment needed;

Disadvantage:
stomach acid reacts with drugs / slow effect / only small fraction of drug absorbed / vomiting / requires conscious patient / harm digestive system/can cause stomach bleeding; ***[2]***

D2. (a) (i) *Bacteria:*
tuberculosis/TB / syphilis / cholera / salmonella / bronchitis / botulism / lyme disease / (stomach) ulcers / anthrax / diptheria / meningitis / MRSA / gonorrhea / chlamydia / septicaemia;

Viruses:
influenza / common cold / AIDS / herpes / rabies / small pox / polio / rubella / yellow fever / measles / mumps / encephalitis / chicken pox / shingles / mononucleosis; ***[2]***

Do not accept name of an organism (such as e-coli) rather than a disease.

(ii) bacteria larger than viruses / viruses are smaller than bacteria;
bacteria are cells / viruses comprise DNA in a protein coat;
bacteria have cell wall/nucleus/cytoplasm / viruses do not have cell components;
bacteria can reproduce without a host / viruses require host/cell for replication/reproduction;
bacteria are not always harmful/parasitic / viruses are always parasitic; ***[3 max]***

(b) patient non-compliance / not completing courses / *OWTTE*;
overprescription;
use for animals/in animal feedstock; ***[2 max]***
Accept overuse.
Do not accept overdose.

(c) 4-membered ring/β-lactam ring;
easily broken / very reactive / highly strained ring;
binds to proteins/deactivates proteins that form cell wall / interferes with cell wall formation / prevent formation of crosslinks within cell wall;
makes cell wall porous / allows water to pass;
causes cell to burst; ***[4 max]***

(d) becomes part of DNA of virus / alters virus DNA/genetic material / blocks enzyme (polymerase) which builds DNA;
changes the cell membrane so that it inhibits the virus entry/bonding to the cell;
prevents virus from leaving the cell (after reproduction);
prevents virus from using cell to multiply/reproduce/replicate; ***[2 max]***

D3. (a) can model (three-dimensional) shape/3D pharmacophore of drug molecule;
Allow molecular modelling.

can model interaction/activity of the drug with target molecule / *OWTTE*;
can predict how changes affect interaction with target molecule / *OWTTE*; ***[2 max]***

(b) one enantiomer/isomer of thalidomide relieves nausea/morning sickness;
other enantiomer/isomer of thalidomide causes foetal deformities;

OR

one enantiomer/isomer of taxol is an anti-cancer drug;
other enantiomer/isomer of taxol is ineffective;

OR

cis-isomer of diamminedichloroplatinum(II)/cisplatin is an anti-cancer drug;
trans-isomer is ineffective; ***[2]***

(c) techniques, such as split and mix, used to produce random combinations;
chemical building blocks joined to each other in many combinations / *OWTTE*;
produces large variety of molecules/combinatorial libraries/collection of compounds / *OWTTE*;
these molecules may be screened for physiological activity/drug action; ***[2 max]***

Option E — Environmental chemistry

E1. (a) oxygen has double bond/bond order 2;
ozone has delocalized bond/bond order 1.5;
oxygen bond/bond in oxygen (molecule) is stronger/shorter / ozone bond is weaker/longer;
ozone absorbs light of lower energy/lower frequency/longer wavelength; ***[3 max]***
Accept suitable diagram.

(b) $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$;
$NO_2(g) \xrightarrow{(hf/h\nu/\text{UV/sunlight})} NO(g) + O\bullet(g)$;
$NO_2(g) + O\bullet(g) \rightarrow NO(g) + O_2(g)$;
$NO_2(g) + O_3(g) \rightarrow NO(g) + 2O_2(g)$;
$O_3(g) + O\bullet(g) \rightarrow 2O_2(g)$; ***[2 max]***

(c) nitrogen monoxide produced in car engines;
nitrogen dioxide produced from nitrogen monoxide reacting with oxygen;
oxygen atoms/ozone formed from action of sunlight on nitrogen dioxide;
oxygen atoms react with oxygen molecules;
powerful oxidizing agent that can oxidize organic compounds (such as VOCs) / *OWTTE;*
concentrations decrease as ozone reacts (with other pollutants) / sunlight decreases;
PANs formed by reaction of VOCs/organic pollutants with ozone;
[3 max] *for stages involved.*

$N_2(g) + O_2(g) \rightarrow 2NO(g)$;
$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$;
$NO_2(g) \xrightarrow{(hf/h\nu/\text{UV/sunlight})} NO(g) + O\bullet(g)$;
$O\bullet(g) + O_2(g) \rightarrow O_3(g)$; ***[5 max]***
[3 max] *for relevant equations.*
Give credit for correct equations showing the reaction of organic molecules reacting with radicals to form PANs etc.

E2. (a) dissolved carbon dioxide / $CO_2(g) + H_2O(1) \rightleftharpoons H_2CO_3(aq)$;
$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$ / $CO_2(aq) + H_2O(1) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$; ***[2]***

(b) (i) internal combustion engine / high temperature combustion;
$N_2(g) + O_2(g) \rightarrow 2NO(g)$; ***[2]***

(ii) catalytic converters / exhaust recirculation;
$2NO(g) + 2CO(g) \rightarrow N_2(g) + 2CO_2(g)$; ***[2]***

(iii) nitric acid/HNO_3 / nitrous acid/HNO_2; ***[1]***

E3. (a) *Any two for first two marks:*
plant/animal tissue;
decay products of plant/animal/organic matter;
high-molecular-mass organic material/polysaccharides/proteins;
simple organic material/sugars/amino acids;
humic substances/humus;

Any one for third mark:
provide source of nutrients;
improves structural stability;
source of energy;
influences water retention properties / retains water/moisture;
alters thermal properties / retains heat;

Any one for final mark:
cation exchange capacity/CEC;
binds toxic metals (ions)/cations/pollutants;
acts as buffer; ***[4 max]***

(b) in nature nutrients (such as N, K or P) return to soil when plant dies / *OWTTE*;
harvesting/removal of plants removes nutrients;
adding fertilizers/compost / crop rotation / leave soil fallow; ***[3]***

(c) pesticides / insecticides / (selective) herbicides / fungicides; ***[1]***

Option F — Food chemistry

F1. (a) (sugar free chewing) gum / emulsifiers / synthetic antioxidants / food colourings / food flavourings / pepper;
Do not accept "additives".

Food: (substance) intended for (human) consumption;

Nutrient: (substance) obtained from food that provides energy/regulates growth/maintenance and repair; ***[3]***

(b) (i) conjugation / extended systems of delocalized (π-)bonding;
electrons excited/promoted/move to higher energy level;
absorb <u>visible</u> light;
complementary colour observed; ***[3 max]***

(ii) sp^3 carbon/four bonded carbon disrupts delocalization/conjugation / the pseudobase has lost some of its conjugation / conjugation has been disrupted / *OWTTE*; ***[1]***

(c) β-carotene absorbs light in blue/green region;
colour of light reflected/transmitted therefore red/orange; ***[2]***

(d) anthocyanins tend to be water soluble whereas carotenes tend to be oil/fat soluble;
anthocyanins contain hydroxyl/polar/ionic groups/groups that can hydrogen-bond;
carotenes do not contain polar groups / carotenes have long hydrocarbon chains; ***[3]***

F2. (a) hydrolytic rancidity **and** oxidative rancidity;
hydrolytic rancidity involves (reaction with water) breaking ester bond / formation of a fatty acid and glycerol / *OWTTE*;
oxidative rancidity involves reaction of carbon-carbon double bond/C=C with oxygen / addition reaction with oxygen; ***[3]***

(b) (oxidation) involves (free) radicals;
molecules (such as THBP and TBHQ) react with (free) radicals;
(free) radicals react with them/THBP and TBHQ to form stable products; ***[2 max]***

(c) *Award **[2]** for any one of the following combinations.*

Compound: vitamin C;
Food: fruit / vegetables;
Accept the name of a specific example.

Compound: vitamin E;
Food: nuts / seeds / grains / vegetable oils / leafy vegetables;
Accept the name of a specific example.

Compound: β-carotene;
Food: carrots / squash / tomatoes;

Compound: selenium;
Food: fish / shellfish / red meat / eggs;

Final mark for any of the following:
Benefit: lowering LDL cholesterol / reducing blood pressure / preventing cancer / reducing heart diseases; ***[3 max]***

F3. (a) (kinetically) stable mixture of two immiscible phases; ***[1]***
Accept colloid/colloidal system.

(b) <u>both</u> liquids; ***[1]***

(c) molecule contains both hydrophilic and hydrophobic parts/groups;
one part attracted to/joins to non-aqueous/oil phase;
one part attracted to/joins to water/aqueous phase;
behaves as surfactant / acts as a bridge between the phases;
stabilizes junction between phases; ***[3 max]***

Option G — Further organic chemistry

G1. (a) both reactions increase the length of the carbon chain / result in the formation of a new C–C bond / form a 3-carbon chain product from a 2-carbon chain reactant; ***[1]***

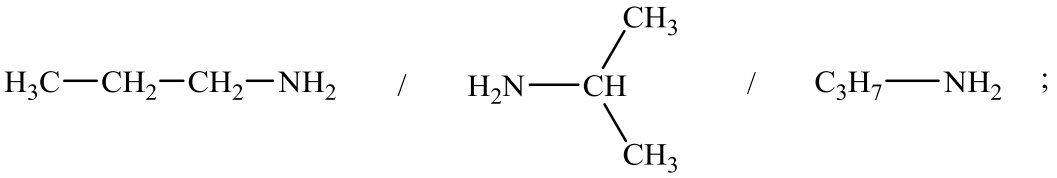
(b) C_2H_5–Mg–I/C_2H_5MgI; ***[1]***

(c) *Reaction **I**:*
magnesium/Mg;

*Reaction **II**:*
carbon dioxide/CO_2;
water/H_2O / H_3O^+ / H^+; ***[3]***

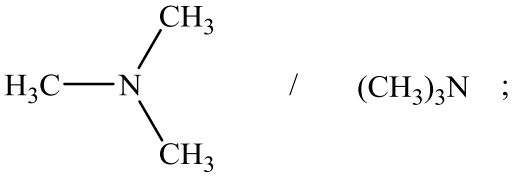
(d) hydroxypropanoic acid/$CH_3CHOHCOOH$/product of reaction **IV**;
OH electron withdrawing/has –I effects;
weakens/further polarizes OH bond (of COOH) / stabilizes anion/conjugate base; ***[3]***

G2. (a) *Primary*



Secondary

Tertiary



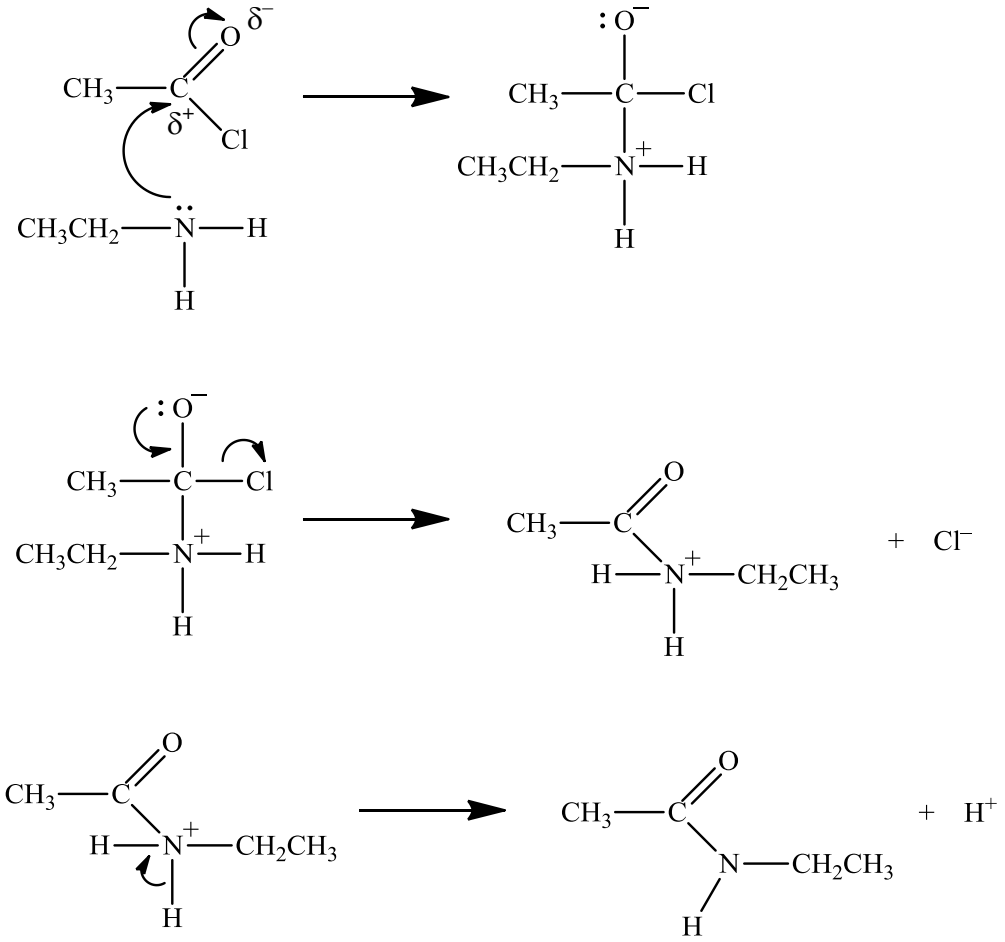
[3]

Accept CH_3– instead of H_3C– and NH_2– instead of H_2N–.

(b) the methyl/alkyl group is electron donating/releasing / has a +I effect;
increases the electron density on N / therefore repulsion on the lone pair increases making it more ready to accept a proton/H^+; ***[2]***

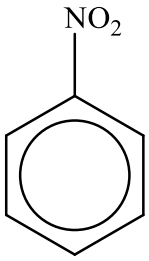
(c) $2C_2H_5NH_2 + CH_3COCl \rightarrow C_2H_5NHCOCH_3 + C_2H_5NH_3Cl$; ***[1]***
Accept $C_2H_5NH_2 + CH_3COCl \rightarrow C_2H_5NHCOCH_3 + HCl$.

(d)



curly arrow going from lone pair on N to carbonyl C **and** curly arrow going from C=O bond to O;
representation of intermediate showing negative charge on O **and** positive charge on N;
curly arrow going from lone pair /negative charge on O to C–O to form C=O **and** curly arrow showing Cl leaving;
curly arrow going from NH bond to N^+ **and** formation of $H_3CCONH(CH_2CH_3)$ **and** Cl^- **or** H^+; ***[4]***

G3. (a)



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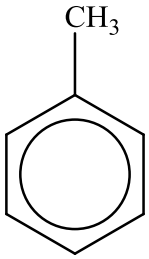
Product 1



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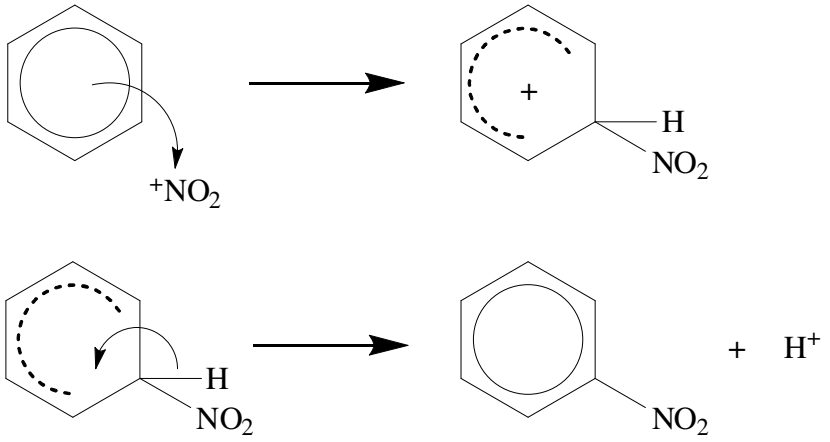
Product 2 ***[2]***

(b) (i) $HNO_3 + 2H_2SO_4 \rightleftharpoons NO_2^+ + 2HSO_4^- + H_3O^+$ /
$HNO_3 + H_2SO_4 \rightleftharpoons NO_2^+ + HSO_4^- + H_2O$; ***[1]***

(ii)



curly arrow going from delocalized electrons in benzene to $^+NO_2$;
Do not penalize if NO_2^+ is written.

representation of carbocation with correct formula and positive charge on ring;
curly arrow going from CH bond to benzene ring cation;
formation of organic product nitrobenzene **and** H^+; ***[4]***
Allow mechanism with corresponding Kekulé structures.