



MARKSCHEME

May 2012

CHEMISTRY

Standard Level

Paper 3

18 pages

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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 SL Paper 3 Markscheme

Mark Allocation

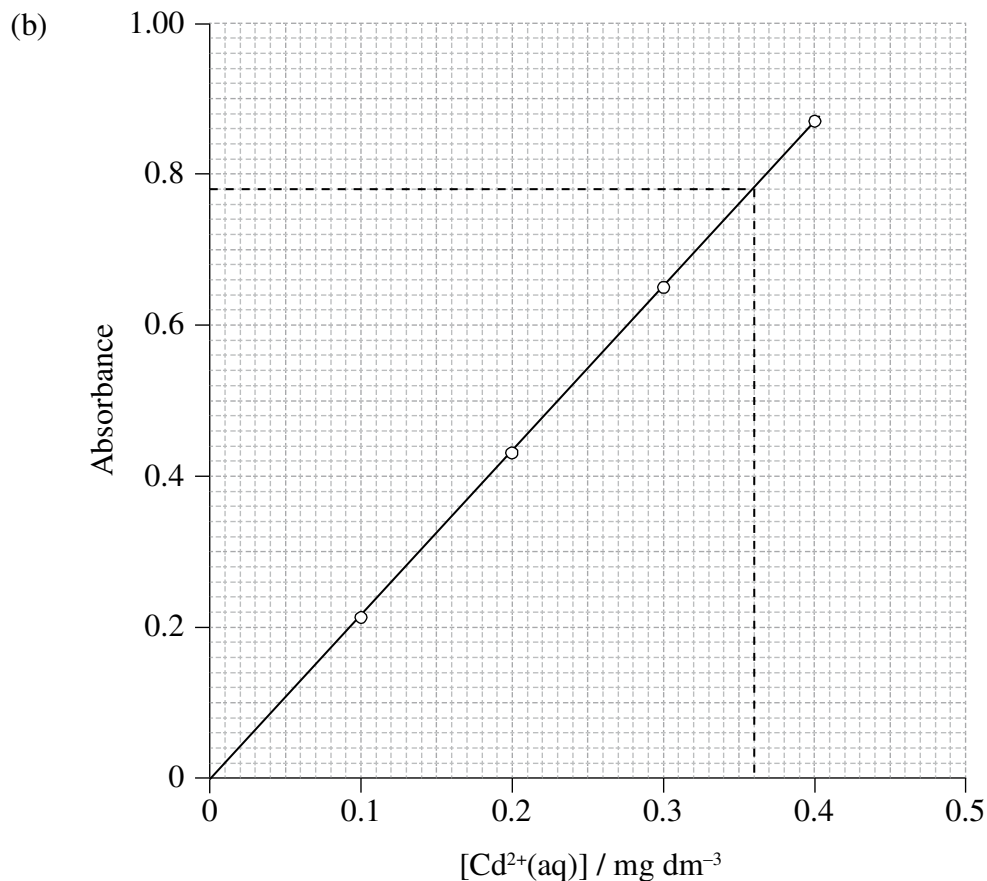
Candidates are required to answer questions from **TWO** of the options [**2 x 20 marks**]. Maximum total = [**40 marks**].

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 markscheme, similarly, if the formula is specifically asked for, unless directed otherwise in the markscheme 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) change the (monochromatic) light source/wavelength/frequency;
from cadmium (atoms/ions) to mercury (atoms/ions) / *OWTTE*;

[2]



correct labelling showing concentration (of cadmium ions) with units **and** appropriate scales;

Do not penalize for use of smaller but consistent divisions.

correct plotting **and** straight line through the origin;

concentration of Cd²⁺ (from graph) = 0.36 (mg dm⁻³);

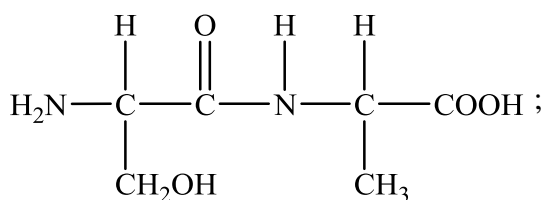
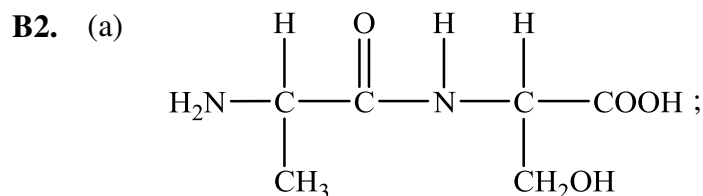
[3]

Allow answer in range 0.35 to 0.37 (mg dm⁻³).

- A2.** (a) components are adsorbed onto (solid) stationary phase/alumina/ Al_2O_3 ;
components dissolve in mobile phase/propanone / components partition between stationary phase and mobile phase/propanone;
separation depends on different abilities of the components to adsorb and dissolve/partition / *OWTTE*; [3]
- (b) *Any three for first three marks:*
mixture dissolved in propanone/eluent/solvent and added to top of column (packed with alumina/ Al_2O_3) / mixture placed on top of column;
propanone/eluent/solvent (continually) added to top of column;
components collected separately as they leave column;
components move at different rates/have different retention times;
propanone/eluent/solvent is removed (by evaporation);
- Required for final mark:*
components are weighed / use UV absorption/fluorescence to measure the concentration of components / *OWTTE*; [4 max]
- A3.** (a) both 1-bromobutane and 2-bromobutane have four peaks;
(ratio of areas in) 1-bromobutane: 3:2:2:2;
(ratio of areas in) 2-bromobutane: 3:1:2:3; [3]
For second and third points accept correct ratios given in a different order.
Accept correct number of hydrogen atoms for each peak instead of area.
- (b) three peaks (not four);
ratio of areas/integration trace: 6:1:2; [2]
Accept correct ratio given in a different order.
- (c) protons/hydrogens in water/lipids/carbohydrates (within cells) can be detected by (^1H) NMR/MRI;
to give a (three-dimensional) view/image of organs/body;
protons/hydrogens in cancerous cells are in a different chemical environment so give different signals; [3]

Option B — Human biochemistry

- B1.** (a) chemical messenger / chemical (produced in endocrine glands) transported through the blood to site of action; [1]
- (b) thyroxine; [1]
Do not accept iodine.
- (c) (i) testes/testicles; [1]
- (ii) testosterone contains an alcohol/hydroxyl/hydroxy group / progesterone does not contain an alcohol/hydroxyl/hydroxy group; progesterone contains two carbonyl/ketone groups / a carbonyl/ketone group in place of the alcohol; [2]
Do not accept formulas such as –OH or C=O.
- (d) (i) dianabol contains an extra methyl/CH₃ group; dianabol contains an extra alkene/carbon to carbon double bond/is more unsaturated/is more conjugated; dianabol contains a tertiary alcohol **and** testosterone contains a secondary alcohol; [1 max]
- (ii) dianabol also has structural similarities to progesterone/estradiol/female sex hormones / *OWTTE*; [1]



Accept –CO–NH– as an abbreviation for $\begin{array}{c} \text{O} & \text{H} \\ || & | \\ -\text{C} & - & \text{N}- \end{array}$

[2]

- (b) (i) *Trp and Leu:*
 van der Waals' forces / London forces / dispersion forces /
 temporary/induced dipole-dipole interactions;
Do not accept just dipole-dipole attractions.
Cys and Cys:
 (di)sulfide bridge(s) / covalent bond between S atoms;
Tyr and His:
 hydrogen bonding; [3]
- (ii) ionic bonding / peptide/amide bond; [1]
- (c) interaction between (separate) chains/molecules/polypeptide chains (to give a more complex structure); [1]
- B3.** (a) (i) saturated fats / fats derived from lauric/myristic/palmitic acid / the liver; [1]
- (ii) remove cholesterol from the arteries / transport cholesterol to the liver / protect against heart attack/disease; [1]
- (b) (i) both unsaturated fatty acids;
 linoleic acid has one less C=C bond/carbon to carbon double bond/is less unsaturated / linolenic acid has one more C=C bond/carbon to carbon double bond/is more unsaturated;
 in linoleic the first C=C bond occurs further from the end of hydrocarbon chain / in linolenic the first C=C bond occurs closer from the end of hydrocarbon chain;
 both contain 18 carbon atoms; [3 max]
- (ii) body unable to synthesize them; [1]

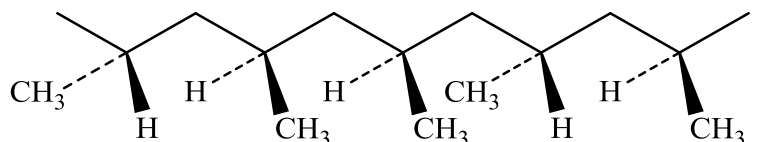
Option C — Chemistry in industry and technology

- C1.** (a) (i) scrap iron/steel;
lime/calcium oxide/CaO;
aluminium/Al;
magnesium/Mg; **[2 max]**
- (ii) P and Si first converted into their oxides/reacted with oxygen /
 $4P + 5O_2 \rightarrow P_4O_{10}$ / $Si + O_2 \rightarrow SiO_2$;
then combine with lime/CaO to form slag/ $Ca_3(PO_4)_2$ /CaSiO₃/calcium
phosphate/calcium silicate; **[2]**
Accept balanced chemical equations.
- (b) their atoms/ions have similar/slightly different radii/size/densities/properties;
so do not disrupt crystal structure/metallic lattice significantly / *OWTTE*; **[2]**
- (c) steel is heated (to a high temperature/about 1000 °C) **and** then cooled slowly;
makes steel more ductile / less brittle / more malleable / easier to work with; **[2]**
- C2.** (a) (+) *electrode (cathode)*: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$;
(-) *electrode (anode)*: $H_2 + 2OH^- \rightarrow 2H_2O + 2e^-$; **[2]**
- (b) (+) *electrode (cathode)*: $PbO_2 + 4H^+ + SO_4^{2-} + 2e^- \rightarrow PbSO_4 + 2H_2O$;
(-) *electrode (anode)*: $Pb + SO_4^{2-} \rightarrow PbSO_4 + 2e^-$; **[2]**
- (c) (i) fuel cells produce only water / Cd and Ni are toxic (heavy metals); **[1]**
- (ii) fuel cells can operate continuously/do not need recharging;
fuel cells are more unwieldy/less portable/less self-contained/need supply of
O₂ and H₂; **[1 max]**
Accept opposite statements for NiCd cells.

- C3. (a) HDPE has little branching whereas LDPE has branching/side chains / *OWTTE*;
 HDPE is stronger/more rigid / LDPE is weaker/more flexible/resilient;
 HDPE chains pack more closely together / LDPE chains pack less closely together;
 HDPE has stronger van der Waals' forces / LDPE has weaker van der Waals' forces;

[3 max]

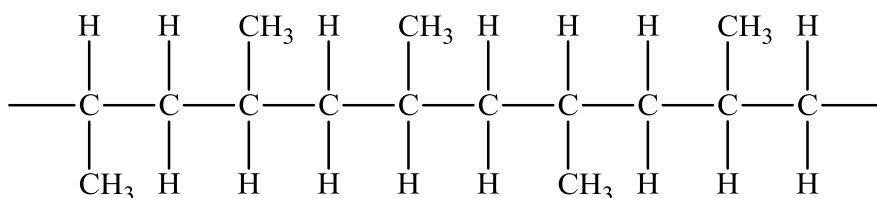
- (b) (i)



[1]

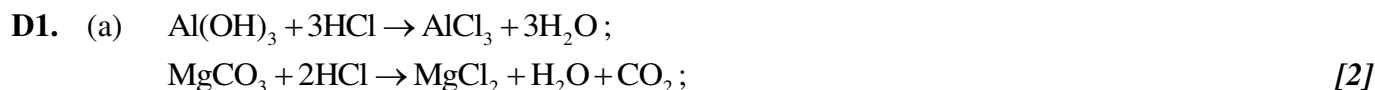
There must be five -CH₃ groups and they must be shown in random orientation.

Allow the following structure:



- (ii) isotactic has all methyl groups oriented/pointing in the same direction/has a more regular structure / atactic has the methyl groups oriented/pointing in different directions/arranged randomly/has an irregular structure;
 in isotactic the chains can pack more closely together (making it more crystalline/tough) / in atactic the chains pack less closely together (making it soft/flexible);
 isotactic has stronger van der Waals' forces / atactic has weaker van der Waals' forces;

[2 max]

Option D — Medicines and drugs

(b) $n \text{ Al(OH)}_3 = \frac{0.160}{77.95} = 2.05 \times 10^{-3} \text{ (mol)}$
and $n \text{ MgCO}_3 = \frac{0.105}{84.32} = 1.25 \times 10^{-3} \text{ (mol)}$;

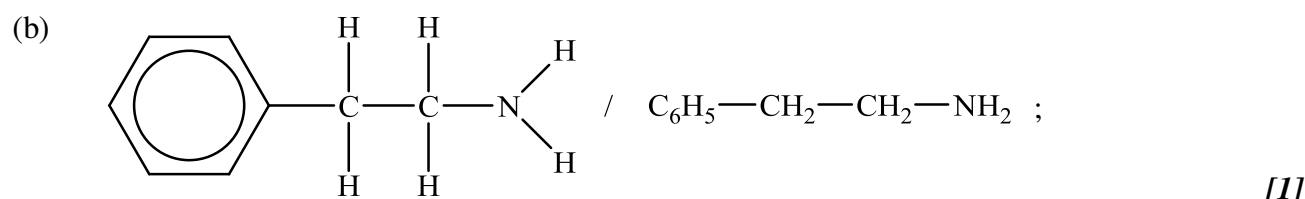
Do not penalize use of integer values for M_r .

Al(OH)_3 neutralizes 6.15×10^{-3} mol of acid **and**
 MgCO_3 neutralizes 2.50×10^{-3} mol of acid; [2]

(c) produces a neutralizing layer / prevents heartburn/reflux/acid rising into the esophagus; [1]

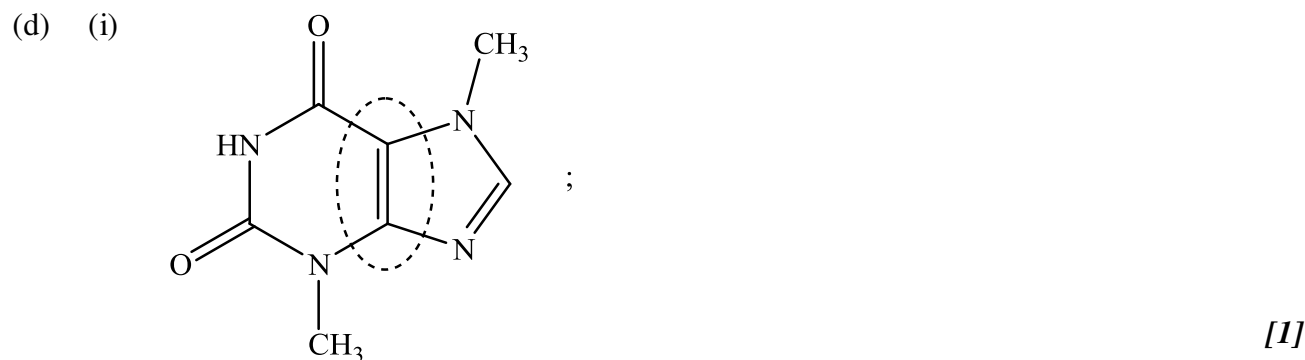
(d) due to carbon dioxide (from reaction of $\text{MgCO}_3/\text{NaHCO}_3$ with acid); [1]

D2. (a) mimics the action of epinephrine/adrenaline; [1]



Accept $\text{C}_6\text{H}_5\text{—NH—C}_2\text{H}_5$ and $\text{C}_6\text{H}_5\text{CH(CH}_3\text{)NH}_2$ in condensed or full structural formulas.

(c) both amines;
 amphetamine contains primary amine/two H atoms on N/one R-group on N **and**
 epinephrine/adrenaline contains secondary amine/one H atom on N/two R-groups on N; [2]



(ii) amide; [1]

(iii) tertiary amine; [1]

- D3.** (a) left (a petri dish containing) bacteria, upon his return noticed that mould had inhibited bacterial growth / a (penicillin) mould came in a window while he was away and inhibited growth of bacteria / *OWTTE*; **[1]**
- (b) overcame problems associated with isolating/concentrating penicillin;
showed that penicillin is harmless and effective on mice;
developed techniques to purify penicillin / prepared it in crystalline form;
first to use penicillin on a policeman/person (dying of septicaemia);
grew strains of penicillin in bulk/large amounts;
used corn-steep liquor (for mould to grow); **[3 max]**
- (c) *Two of these for first two marks:*
interferes with enzymes/chemicals that bacteria need to make (normal) cell walls /
interferes with cell wall formation (in bacteria);
osmotic pressure causes (weakened) cell wall to break/burst / water enters cell
causing it to burst / *OWTTE*;
 β -lactam ring is strained/reactive;
- Required for final mark:*
bacteria become resistant to penicillins/produce the enzyme penicillinase /
OWTTE; **[3 max]**

Option E — Environmental chemistry

- E1.** (a) *Carbon monoxide:*
incomplete combustion/not enough oxygen (for complete combustion);
Accept a balanced equation for the incomplete combustion of a hydrocarbon.
- Oxides of nitrogen:*
combination of nitrogen and oxygen at high temperatures; [2]
Do not accept just combination of nitrogen and oxygen.
Accept a balanced equation for the formation of NO/NO₂ as long as high temperature is mentioned.
- (b) unburned gasoline/petrol/hydrocarbons/volatile organic compounds/VOCs/sulfur dioxide/SO₂; [1]
- (c) *Substance:*
platinum/Pt / rhodium/Rh / palladium/Pd;
- Equation:*
$$2\text{CO} + 2\text{NO} \rightarrow 2\text{CO}_2 + \text{N}_2$$

correct reactants **and** products;
correctly balanced equation; [3]
- (d) *For increase in fuel/air ratio:*
decreases NO_x;
leads to an increase in CO/C/gasoline/petrol/hydrocarbons/volatile organic compounds/VOCs / lowers efficiency / OWTTE; [2]
Accept opposite statements for decrease in fuel/air ratio.
- E2.** *Soil pollution:*
due to increasing use of pesticides/fertilizers;
reduce soil diversity/disrupt soil food web;
- Nutrient depletion:*
due to harvesting of crops/agricultural use;
removes nutrients/minerals required for healthy plant growth;
- Salinization:*
irrigation leaves salt(s) in soil (after water evaporates);
salts are toxic/hinder or prevent plant growth/prevent plants from taking in water (through roots); [6]

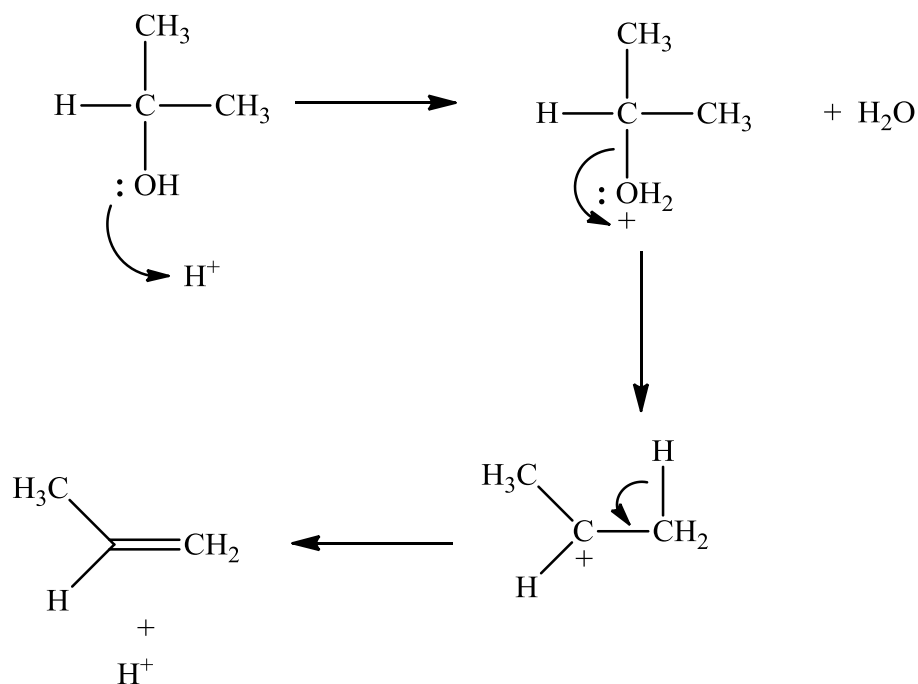
- E3.** (a) amount/measure of dissolved oxygen (measured in ppm) required to decompose organic matter (in water biologically);
over a set time period/5 days; [2]
- (b) *Aerobic decomposition:*
phosphate (ion)/ PO_4^{3-} ;
- Anaerobic decomposition:*
phosphine/phosphorus hydride/ PH_3 ; [2]
- (c) metabolic rate increases / oxygen demand (of fish) increases;
solubility of oxygen in water decreases / availability of oxygen decreases /
OWTTE;
fish die; [2 max]

Option F — Food chemistry

- F1.** (a) time until the food no longer maintains the expected quality desired by consumer / *OWTTE*; [1]
- (b) (i) carbon to carbon double bond / $C=C$; [1]
- (ii) rancid; [1]
- (iii) forms (free) radicals / breaks bonds homolytically/homolytic bond fission; [1]
- (c) phenol (group) / $-C_6H_5-OH$;
tert-butyl/2-methylpropyl (group) / $-C(CH_3)_3$; [2]
Do not accept ether, alcohol or benzene ring.
- (d) phenol (group) / $-C_6H_5-OH$; [1]
- F2.** (a) oils contain at least one $C=C$ /carbon to carbon double bond;
oils have fewer carbon atoms in the hydrocarbon chains / *OWTTE*; [2]
- (b) hydrogenation / react with hydrogen (gas);
heat/140–225 °C **and** metal catalyst/Ni/Zn/Cu/pressure; [2]
- (c) *Advantages: [2 max]*
increases melting points / changes oil to a semi-solid/solid;
decreases rate of oxidation;
increases hardness;
controls feel/plasticity/stiffness;
- Disadvantages: [2 max]*
the more saturated the less good for the heart / *OWTTE*;
trans-fatty acids can be formed (through partial hydrogenation);
trans-fatty acids are difficult to metabolize / increase LDL levels / low quality
energy source / accumulate in fatty tissue / are difficult to digest/excrete (from the
body); [4 max]
- F3.** (a) soluble in fat/oil **and** water / hydrophobic **and** hydrophilic; [1]
- (b) mechanical action/energy / dispersing/mixing oil and water (is needed to make an
emulsion); [1]
- (c) prevent emulsions/foams from separating (into separate phases); [1]
- (d) may be harmful to health/carcinogenic;
food crosses international borders so need for uniformity with labelling/
regulations / *OWTTE*; [2]

Option G — Further organic chemistry

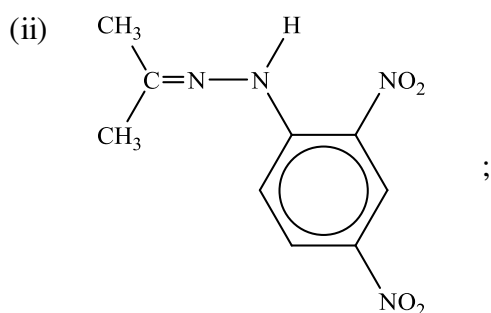
G1. (a)



curly arrow going from lone pair on O to H^+ ;
 representation of positively charged O intermediate **and** curly arrow showing H_2O leaving;
 curly arrow going from CH bond to $C-C^+$ to form $C=C$;
No mark awarded if C^+ is not represented.

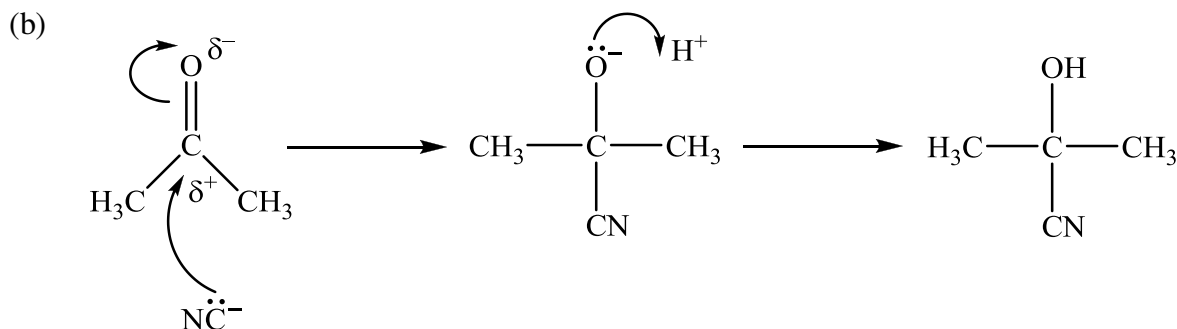
formation of organic product $CH_3HC=CH_2$; [4]
 Accept arrow to H of H_3PO_4 or H_2SO_4 in first step.
 Accept use of $H_2O/H_2PO_4^-/HSO_4^-$ to remove H^+ in third step.

(b) (i) addition-elimination / condensation; [1]



[1]

- G2. (a) (nucleophilic) addition; [1]
Do not award mark for electrophilic addition.



curly arrow going from lone pair /negative charge on C in NC^- to carbonyl C **and** curly arrow going from $\text{C}=\text{O}$ to O;
Do not allow curly arrow originating on N of NC^- .

representation of intermediate anion with negative charge on O;
curly arrow going from lone pair/negative charge on O of intermediate anion to H^+ ;
formation of organic product $(\text{CH}_3)_2\text{C}(\text{OH})\text{CN}$; [4]

- (c) hydrolysis / adding acid / H^+ ; [1]
- (d) (i) $\text{C}_3\text{H}_7\text{MgBr}$; [1]
(ii) $\text{C}_3\text{H}_7\text{C}(\text{CH}_3)_2\text{OH}$; [1]
Accept full or condensed structural formulas for (d) (i) and (d) (ii).

- G3. (a) methyl group has a positive inductive effect/is electron releasing/pushes electrons towards the N atom; (increases the electron density on N atom) so it attracts a proton more strongly / stabilises the $\text{CH}_3\text{NH}_3^+/\text{RNH}_3^+$ ion / *OWTTE*; [2]
- (b) two ethyl/R groups have a greater positive inductive effect than one / *OWTTE*; [1]
- (c) hydrocarbon chain is non-polar (so reduces the solubility of the amine in water) / *OWTTE*;
forms an ionic salt (in HCl) / $\text{C}_5\text{H}_{11}\text{NH}_2 + \text{HCl} \rightarrow \text{C}_5\text{H}_{11}\text{NH}_3^+\text{Cl}^-$; [2]
- (d) $\text{CH}_3\text{NH}_3\text{Cl} + \text{NaOH} \rightarrow \text{CH}_3\text{NH}_2 + \text{NaCl} + \text{H}_2\text{O}$; [1]