M12/4/CHEMI/HP3/ENG/TZ2/XX/M

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MARKSCHEME

May 2012

CHEMISTRY

Higher Level

Paper 3

21 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.

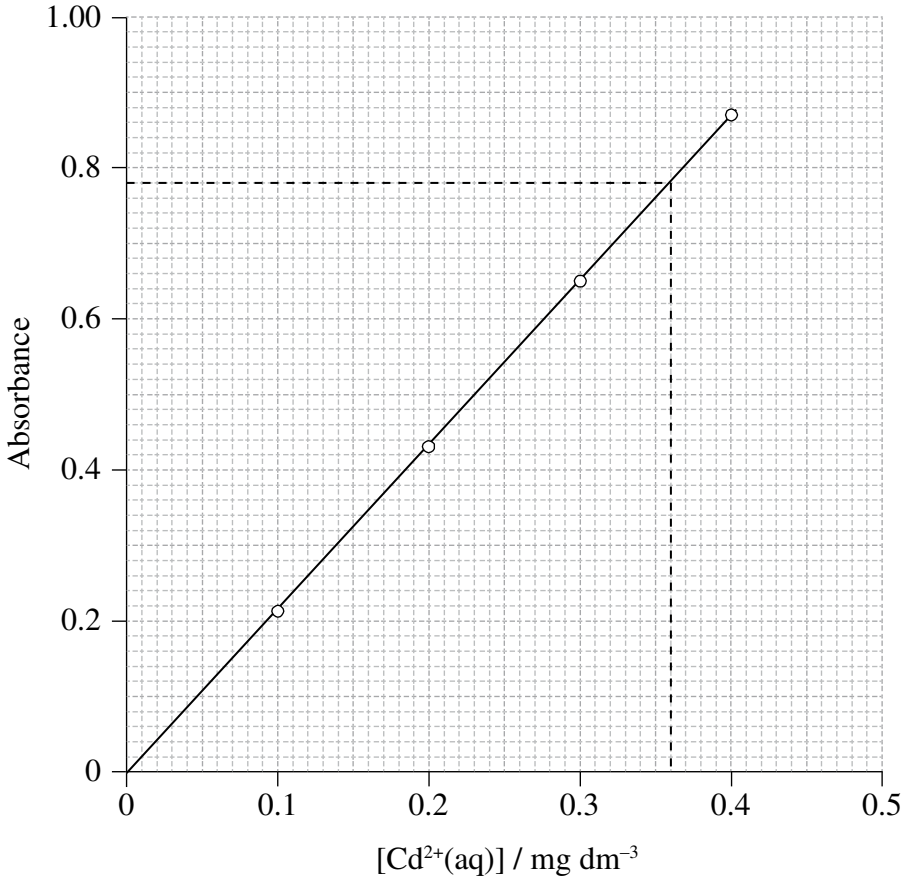
12. If a question asks for an equation for a reaction, a balanced symbol equation is usually expected, do not award a mark for a word equation or an unbalanced equation unless directed otherwise in the markscheme.

13. Ignore missing or incorrect state symbols in an equation unless directed otherwise in the markscheme.

Option A — Modern analytical chemistry

A1. (a) change the (monochromatic) light source/wavelength/frequency;
from cadmium (atoms/ions) to mercury (atoms/ions) / *OWTTE*; ***[2]***

(b)



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 Cd^{2+} (from graph) $= 0.36\,(\text{mg dm}^{-3})$; ***[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) *Number of peaks*:
1;

Splitting pattern:
singlet / it is not split; ***[2]***

(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]***

A4. (a) oxidation state of transition element/number of d electrons/charge on ion;
type/identity/charge density of ligands;
stereochemistry/shape of complex/number of ligands; ***[2 max]***

(b) molecule colourless because energy absorbed in UV region/not absorbed in visible region;
anion pink because of greater conjugation/more alternating single and double (C=C) bonds;
anion/coloured form/more conjugated form absorbs in visible region/lower energy radiation/green light;
complementary colour seen; ***[3 max]***

Option B — Human biochemistry

B1. (a) chemical messenger / chemical (produced in endocrine glands) transported through the blood to site of action; ***[1]***

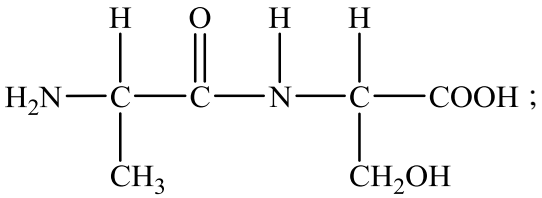
(b) swelling of thyroid gland / goitre / hypothyroidism / Hashimoto's thyroiditis / lethargy / sensitivity to cold / dry skin / memory impairment / weight gain / diminished sex drive / migraine/headaches / depression/anxiety / abnormal menstrual cycles / reproductive difficulties/ infertility; ***[1]***

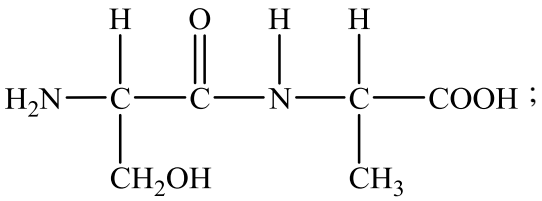
(c) testosterone contains an alcohol/hydroxyl/hydroxy group / progesterone does not contain an alcohol/hydroxyl/hydroxy group;
progesterone contains two carbonyl/ketone groups / a carbonyl/ketone group in place of the alcohol; ***[2]***
Do not accept formulas such as –OH or C=O.

(d) (i) dianabol contains an extra methyl/CH_3 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]***

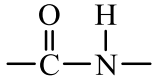
(ii) dianabol also has structural similarities to progesterone/estradiol/female sex hormones / *OWTTE*; ***[1]***

B2. (a)





[2]

Accept –CO–NH– as an abbreviation for 

(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]***

(d) oxygen joins to/forms dative bond with/acts as ligand with iron (in lungs);
oxygen released/detaches (in cells); ***[2]***

B3. (a) at low substrate concentrations/at first rate is (directly) proportional to (substrate) concentration / *OWTTE*;
Do not accept only qualitative statement such as "rate increases as concentration increases".

at high substrate concentrations/eventually rate reaches maximum/levels off/becomes constant / *OWTTE*;
active sites become blocked/saturated / *OWTTE*; ***[3]***

(b) *Competitive inhibitor:*
V_{max} same;
inhibitor occupies active site;

Non-competitive inhibitor:
V_{max} lower;
inhibitor binds elsewhere causing distortion in shape of active site / *OWTTE*; ***[4]***

In each part, explanation mark cannot be awarded without correct reference to V_{max}.

(c) (i) sketch graph with rate and pH labels and bell-shaped curve (showing rate has maximum); ***[1]***

(ii) (at higher or lower pH value of) charges on enzyme/amino acid (residues) changes;
so (shape of) active site changes / tertiary structure lost / *OWTTE*; ***[2]***

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/$Ca_3(PO_4)_2$/$CaSiO_3$/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) (i) steel is heated (to a high temperature/about 1000 °C) **and** then cooled <u>slowly</u>;
makes steel more ductile / less brittle / more malleable / easier to work with; ***[2]***

(ii) hardens steel / makes it (more) brittle; ***[1]***

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) fuel cells produce only water / Cd and Ni are toxic (heavy metals);
fuel cells are more expensive;
fuel cells can operate continuously/do not need recharging;
fuel cells are more unwieldy/less portable/less self-contained/need supply of O_2 and H_2; ***[2 max]***
Accept opposite statements for NiCd cells.

C3. (a) *Thermotropic:*
show liquid-crystal behaviour over a range of temperatures/at certain temperatures;

Lyotropic:
show liquid-crystal behaviour over a range of concentrations/at certain concentrations; ***[2]***

(b) polar groups/N–O/C≡N help molecules to line up in a common direction / *OWTTE*;
biphenyl groups/benzene rings help to make the molecule rigid/rod-shaped/linear / *OWTTE*;
alkyl/hydrocarbon chains help prevent too close packing/help maintain liquid-crystal state / *OWTTE*; ***[3]***

(c) each pixel contains a liquid-crystal film sandwiched between two glass plates;
glass plates have fine scratches and can polarize light;
liquid-crystal molecules line up to form a twisted arrangement / twisted nematic geometry;
liquid-crystal interacts with (plane-) polarized light which is rotated 90° as it passes through the film;
when two polarizers are aligned (with the scratches) light will pass through and pixel will appear bright;
when a potential difference is applied across the film molecules align with the film losing their twisted structure;
they no longer interact with polarized light and pixel appears dark; ***[5 max]***
Apply OWTTE throughout.

Option D — Medicines and drugs

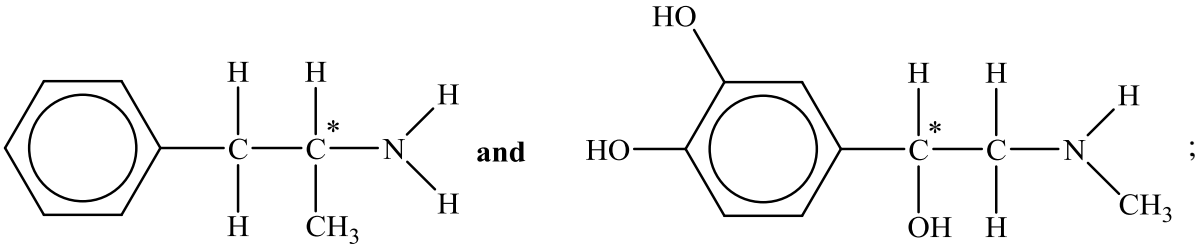
D1. (a) $Al(OH)_3 + 3HCl \rightarrow AlCl_3 + 3H_2O$;
$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$; ***[2]***

(b) $n\ Al(OH)_3 = \frac{0.160}{77.95} = 2.05 \times 10^{-3}$ (mol)
and $n\ MgCO_3 = \frac{0.105}{84.32} = 1.25 \times 10^{-3}$ (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]***

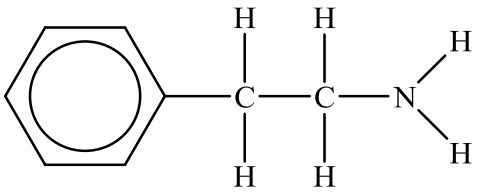
(c) produces a neutralizing layer / prevents heartburn/reflux/acid rising into the esophagus; ***[1]***

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

(b) 

amphetamine ; epinephrine (adrenaline) ***[1]***

(c) enantiomers (in a racemic mixture) may have different physiological effects / *OWTTE*;
one of the enantiomer's effects may be harmful; ***[2]***

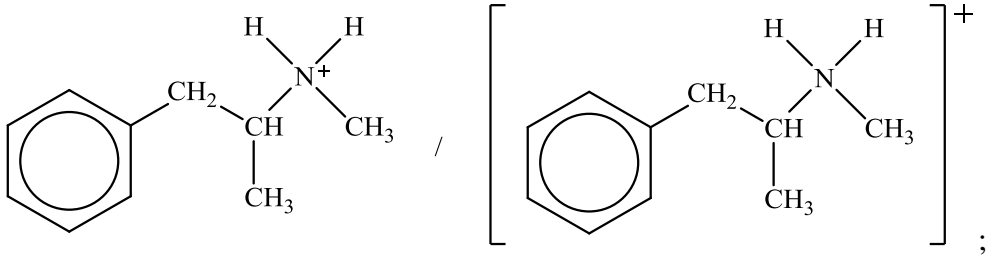
(d) 

/ $C_6H_5—CH_2—CH_2—NH_2$;

[1]

Accept $C_6H_5–NH–C_2H_5$ and $C_6H_5CH(CH_3)NH_2$ in condensed or full structural formulas.

(e) (i) to make it more polar/ionic / to make it soluble (aqueous solutions) / *OWTTE*; ***[1]***

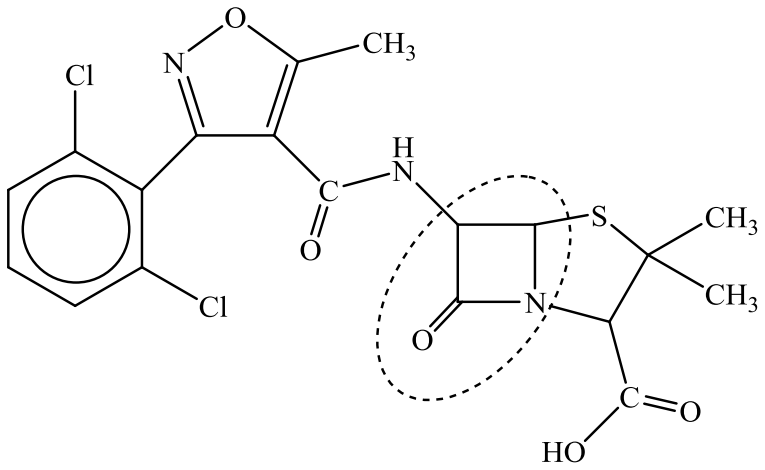
(ii) 

; ***[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) interferes with enzymes/chemicals that bacteria need to make cell walls / interferes with cell wall formation;
osmosis/osmotic pressure causes cell wall to break/burst / water enters cell causing it to burst / *OWTTE*; ***[2]***

(d) (i) 

; ***[1]***

(ii) ring strain / bond angles are approx 90° / should be 109° or 120° / *OWTTE*;
ring breaks / produces reactive amide group / *OWTTE*;
(so) penicillin can become bonded to enzyme/penicillinase; ***[3]***

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

(e) caused by overprescription/overuse/overdose / not completing course of penicillin / use of antibiotics in animal feed / *OWTTE*;
penicillins with modified side chains must be developed/cocktail of drugs must be taken to overcome resistant bacteria / *OWTTE*; ***[2]***

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/NO_2 as long as high temperature is mentioned.

(b) unburned gasoline/petrol/hydrocarbons/volatile organic compounds/VOCs/sulfur dioxide/SO_2; ***[1]***

(c) *Substance:*
platinum/Pt / rhodium/Rh / palladium/Pd;

Equation:
$2CO + 2NO \rightarrow 2CO_2 + N_2$
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) bonds in oxygen are double **and** bonds in ozone are (intermediate) between single and double;
bonds in oxygen are stronger / bonds in ozone are weaker;
oxygen absorbs higher energy UV light / ozone absorbs lower energy UV light; ***[3]***

(b) $NO_2 \xrightarrow{(hf/h\upsilon/UV)} NO + O\bullet$;
$O\bullet + O_3 \rightarrow 2O_2$;
$NO + O_3 \rightarrow NO_2 + O_2$; ***[3]***

(c) water in atmosphere freezes/forms ice / *OWTTE*;
crystals contain small amounts of chlorine-containing molecules/HCl/$ClONO_2$/CFCs;
catalytic reactions occur (on surface of crystals) to form chlorine/Cl_2/HClO;
(sunlight causes) formation of chlorine radicals/Cl•; ***[3 max]***
If no mention of chlorine compounds/chlorine-containing molecules, only M1 can be awarded.

(d) thermal inversion / pollutants trapped by (layer of) warm(er) air;
still air/no wind / sunlight; ***[2]***

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) / $–C_6H_3–OH$;
tert-butyl/2-methylpropyl (group) / $–C(CH_3)_3$; ***[2]***
Do not accept ether, alcohol or benzene ring.

(d) phenol (group) / $–C_6H_3–OH$; ***[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]***

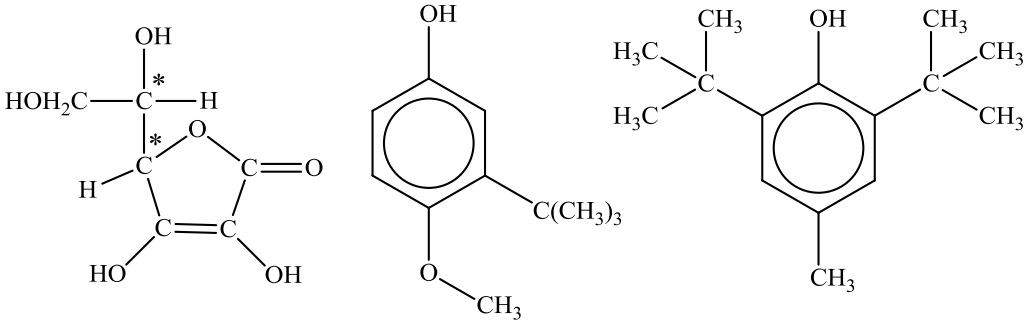
(b) hydrogenation / react with hydrogen (gas);
heat/140−225 °C **and** metal catalyst/Ni/Zn/Cu/pressure; ***[2]***

(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) $C_6H_8O_6 \rightarrow C_6H_6O_6 + 2H^+ + 2e^-$ ***[2]***

(b)



vitamin C 2-BHA BHT ***[2]***

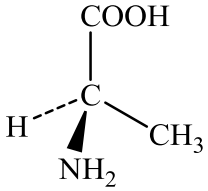
*Award **[1]** for each correctly placed asterisk.*

(c) +(*d*) form rotates plane of polarization (of plane-polarized light) clockwise/to right / –(*l*) form rotates plane of polarization (of plane-polarized light) anticlockwise/to left;

OR

they/both rotate the plane of polarization (of plane-polarized light) by same amount in opposite directions; ***[1]***
Do not accept reflection.

(d) follows the "CORN" rules;
hydrogen atom points away from viewer. If **CO**OH, **R**, **N**H_2 are arranged clockwise it is D form and if anticlockwise it is L form;



; ***[3]***

Accept other correct alternatives if CORN rules not referred to.

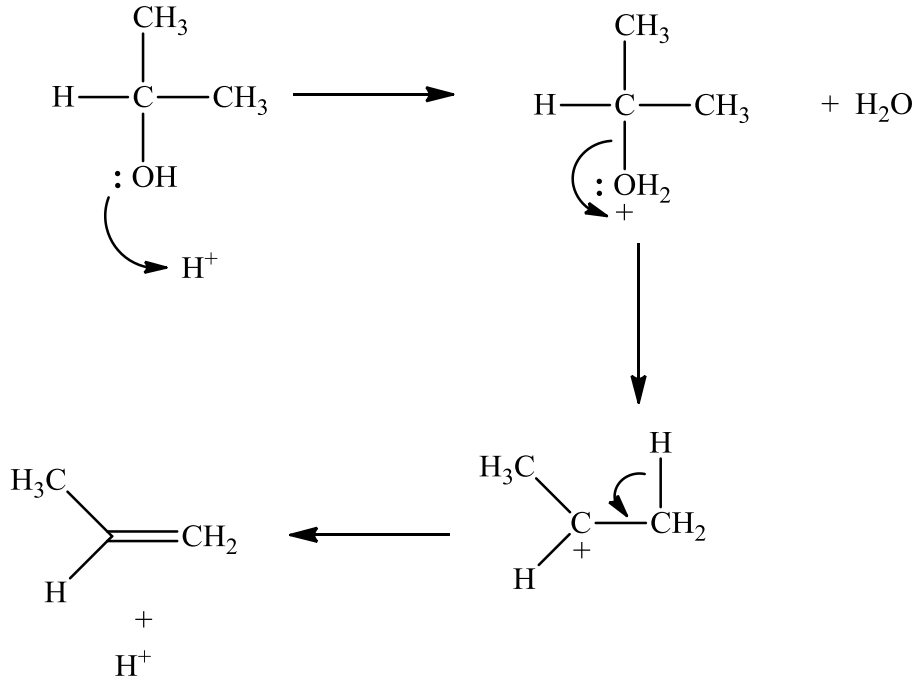
(e) limonene – one form (+(*d*)) smells of oranges;
and other form (–(*l*)) smells of lemons;

OR

carvone – one form (+(*d*)) tastes of caraway seeds/dill;
and other form (–(*l*)) tastes of spearmint; ***[2]***
Accept other correct named example.

Option G — Further organic chemistry

G1. (a)

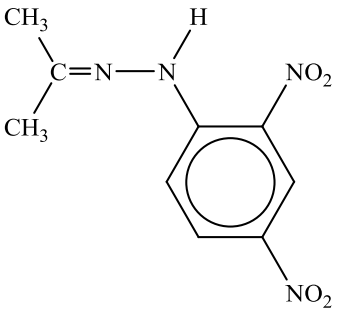


curly arrow going from lone pair on O to H^+;
representation of positively charged O intermediate **and** curly arrow showing H_2O leaving;
curly arrow going from CH bond to $C–C^+$ to form C=C;
No mark awarded if C^+ is not represented.

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]***

(ii)



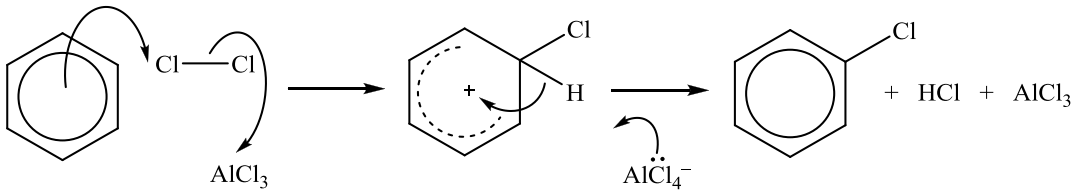
; ***[1]***

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

(b) hydrolysis / adding acid / H^+; ***[1]***

(c) (make) C_3H_7MgBr/Grignard reagent/propyl magnesium bromide;
react C_3H_7MgBr/Grignard reagent/propyl magnesium bromide with carbon dioxide;
followed by reaction with water; ***[3]***
Do not award M3 if carbon dioxide missing.
*Award **[2 max]** if water added before carbon dioxide.*

G3. (a) (i)



curly arrow from benzene ring to Cl^+ (or to Cl- -Cl- -$AlCl_3$ or as shown);
intermediate carbocation with + charge;
curly arrow from C–H bond into ring; ***[3]***
Accept use of $AlCl_4^-$ in third step.
Accept mechanism using Kekulé structure

(ii) methyl group exerts a positive inductive effect / pushes electrons towards the benzene ring / is electron-releasing / increases electron density of ring;
making the benzene ring more susceptible to attack by electrophiles / Cl^+ / *OWTTE*; ***[2]***

(iii) in the 2– and 4– position one of the (resonance hybrid) intermediate carbocations has the positive charge on the carbon atom bonded to the methyl group / *OWTTE*;
Accept a diagram showing this intermediate.

positive inductive effect of the methyl group stabilizes this carbocation / *OWTTE*; ***[2]***

(b) (i) $C_6H_5OH + 3Cl_2 \rightarrow C_6H_2(OH)Cl_3 + 3HCl$;
2,4,6-trichlorophenol; ***[2]***

(ii) non-bonding/lone pair of electrons on O atom delocalize with (pi) electrons of benzene ring;
increasing electron density (so no halogen carrier necessary) / *OWTTE*; ***[2]***

G4. (a) in phenol, electrons on O attracted to ring, (pulling O–H electrons to O and) releasing H^+ more readily / *OWTTE*;
in ethanol, ethyl group releases electrons to O, (strengthening O–H bond and) making it harder to lose H^+ / *OWTTE*;

OR

in ethoxide ion charge is localized on the O atom so it is a strong base/readily accepts H^+ ions/ion destabilised (making ethanol a very weak acid) / *OWTTE*;
in phenoxide ion charge is delocalized over the O atom and benzene ring so it is a weaker base/less readily accepts H^+ ions/ion stabilised (so phenol is stronger acid than ethanol) / *OWTTE*; ***[2]***

(b) NO_2 group is electron withdrawing so makes O–H bond even weaker/releasing H^+ ions more readily/charge on anion is further delocalized / *OWTTE*; ***[1]***