

# Markscheme

**May 2015**

**Chemistry**

**Standard level**

**Paper 3**

18 pages

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## 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.
14. Penalize missing hydrogens or incorrect bond linkages (eg C–H<sub>3</sub>C) once only.

## Option A — Modern analytical chemistry

1. (a)

	<i>Investigation</i>	<i>Technique</i>
A	<i>Determining the sodium ion concentration in bottled water</i>	atomic absorption/AA (spectroscopy);
B	<i>Determining whether an organic molecule contains a C=O bond</i>	infrared/IR (spectroscopy); Accept $^{13}\text{C}$ NMR.
C	<i>Determining the molecular mass of an organic molecule</i>	mass spectrometry/spectroscopy / MS;
D	<i>Determining whether an ink comprises just one compound or a mixture of compounds</i>	paper/column/thin-layer chromatography / TLC; Do <b>not</b> accept just "chromatography"
E	<i>Determining the number of different hydrogen atom environments in a molecule</i>	$^1\text{H}$ NMR(spectroscopy); Accept NMR/proton NMR/nuclear magnetic resonance

[5]

(b) E B A; [1]

2.  $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$ ;  
Accept full or condensed structural formula.

Any two for [2 max] from:

two H (atom)/proton environments;

3:2/2:3 ratio of atoms in these environments;

one environment an alkyl group / one environment next to a carbonyl;

Accept  $-\text{CH}_3$  (0.9–1.0 ppm) /  $-\text{CO}-\text{CH}_2-$  (2.2–2.7 ppm)

[3]

3. (a) peaks at ( $m/z =$ ) 62 **and** 64 / two molecular ion peaks;  
height ratio of molecular ion peaks is 3 : 1;  
peak at ( $m/z =$ ) 27 (due to loss of Cl); [2 max]

Accept peaks at 63/65 ( $^{13}\text{C}$ )/peak(s) resulting from  $^{13}\text{C}$  / peaks at 61/63 (loss of H)/peak(s) resulting from loss of H / peaks at 48/50 (loss of  $\text{CH}_2$ )/peak(s) resulting from loss of  $\text{CH}_2$ / 35/37  $\text{Cl}^+$  as an alternative to final marking point.

(b) absorption at 600 – 800 ( $\text{cm}^{-1}$  C–Cl);  
absorption at 1610 – 1680 ( $\text{cm}^{-1}$   $>\text{C}=\text{C}<$ );  
absorption at 2850 – 3100 ( $\text{cm}^{-1}$  C–H); [2 max]

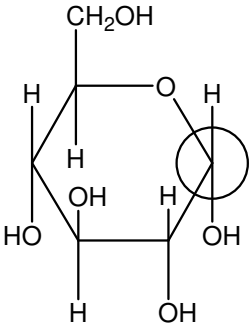
(c) bends/stretch/vibrates;  
change in bond polarity/dipole; [2]

4. (a) (i)  $^1\text{H}$ ; [1]  
*Accept hydrogen/proton/H.*  
*Accept  $^{31}\text{P}$ ,  $^{19}\text{F}$ ,  $^{13}\text{C}$  and other atoms with NMR active nuclei.*
- (ii) different tissues contain different concentrations of water / different compounds / different hydrogen environments / different concentrations of hydrogen atoms/protons/H; [1]  
*Accept "amounts" instead of "concentrations".*
- (b) (i) radio waves; [2]  
(strong) magnetic field;
- (ii) lower frequency / longer wavelength / lower energy; [1 max]  
X-rays can ionize particles/break chemical bonds;  
X-rays can cause tissue damage/cancer/mutations;

**Option B — Human biochemistry**

5. (a) (i) hydrolyse/break peptide bonds;  
heat/boil with (concentrated) hydrochloric acid/HCl; [2]  
*Accept NaOH / enzymes.*
- (ii) 0.50; [1]  
*Accept answers in the range 0.49–0.51.*  
*Accept d/t.*

- (b) structural (protein) / connective/fibrous tissue (in  
 tendons/ligaments/cartilage/skin) / provides elasticity/strength to skin /  
 strengthens blood vessels; [1]

6. (a)  ; [1]

- (b) (i) both have straight chain/C<sub>1</sub> to C<sub>4</sub> linkage;  
 amylose (is a polymer of)  $\alpha$ -glucose **and** cellulose (is a polymer of)  
 $\beta$ -glucose / amylose contains  $\alpha$ -linkages (between monomers) **and**  
 cellulose contains  $\beta$ -linkages (between monomers); [2]

- (ii) humans do not produce cellulase/enzyme that is needed to digest  
 cellulose; [1]

7. (a) assists brain function;  
 enables normal growth/development;  
 involved in synthesis of prostaglandins;  
 reduces (risk of) heart disease/blockage of arteries;  
 lowers blood pressure;  
 reduces LDL cholesterol;  
 increases HDL cholesterol; [2 max]  
*Do **not** accept bad/good instead of LDL/HDL .*

- (b) (i) mass, in g, of iodine/I<sub>2</sub> reacting with 100 g of  
 fat/oil/triglyceride/(unsaturated) substance; [1]  
*Allow "amount/number of mol of iodine/I<sub>2</sub> reacting with 1 mol of  
 fat/oil/triglyceride/(unsaturated) substance."*

- (ii)  $n_{\text{iodine}} = 3n_{\text{linolenic acid}}$  ;  

$$\text{iodine number} \left( = \frac{3 \times 100 \times 253.8}{278.48} \right) = 273(\text{g}) ;$$
 [2]  
*Award [2] for final correct answer.*  
*If an alternative definition, in terms of moles/C=C bonds is given, award  
 [1 max] for iodine number = 3.*

8. (a) calciferol/vitamin D; [1]

(b) ensuring fresh/vitamin-rich/mineral-rich foods present in diet/food (rations);  
genetically modifying food (to increase nutrient levels);  
food additives / adding nutrients to commonly consumed food; [2 max]  
*Accept specific examples.*

9. (a) *Present in both:*  
alkenyl **and** hydroxyl;  
*Accept alkene **and** alcohol/hydroxy but not hydroxide.*

*Present only in aldosterone:*  
carbonyl **and** aldehyde; [2]  
*Accept ketone (for carbonyl).*  
*Accept primary hydroxyl/alcohol.*  
*Award [1 max] if correct formulas, rather than names, given for **both**.*

(b) adrenal cortex/gland; [1]

(c) *progesterone:*  
sexual development in females / menstrual/reproductive cycles in women;

**OR**

*testosterone:*  
sexual development in males; [1]

*Accept any specific function of progesterone/testosterone.*

**Option C — Chemistry in industry and technology**

10. (a)  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{CO}(\text{g}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$  /  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{H}_2\text{O}(\text{g})$  /  
 $2\text{Fe}_2\text{O}_3(\text{s}) + 3\text{C}(\text{s}) \rightarrow 4\text{Fe}(\text{l}) + 3\text{CO}_2(\text{g})$  /  $\text{Fe}_2\text{O}_3(\text{s}) + 3\text{C}(\text{s}) \rightarrow 2\text{Fe}(\text{l}) + 3\text{CO}(\text{g})$ ; [1]  
*Ignore state symbols.*
- (b) (slight) difference in atom/ion size disrupts crystal/lattice structure/layers so  
atoms/ions cannot slide so easily;  
 change in hardness/ductility/malleability/melting point/density; [2]  
*Accept other physical properties.*
- (c) (re)heat (to between 200 °C and 600 °C) **and** cool slowly;  
 becomes more springy/less brittle; [2]  
*Accept more malleable.*
11. (a) increasing cost of oil (relative to other energy sources);  
 limited supply (of petroleum);  
 other sources of energy available / alternative energy sources;  
 (use as a raw material) reduces/delays greenhouse gas/global warming/climate  
 change problems;  
 concerns about greenhouse gases/climate change causing changes in behaviour / *OWTTE*;  
*Do not accept just "greenhouse gases/climate change";*  
 products from raw materials can be recycled / fuels cannot be recycled;  
 increasing demand as raw material from continued economic growth/demand  
 for wider variety of products;  
 more profit to be made (by using as raw material);  
 reduced availability of other sources of hydrocarbons; [2 max]  
*Accept political factors, such as "conflicts disrupting production".*
- (b) *Advantages:*  
*Any two for [2 max] of:*  
 waterproof so strong when wet;  
 can be transparent so contents can be seen;  
 better insulates the item it is packing if expanded plastic/bubble wrap used;  
 can be vacuum sealed to exclude air/keep food fresh;  
 better protection against knocks as it can be moulded to fit the item;
- Disadvantages:*  
*Any one of:*  
 uses valuable petroleum resources which are non-renewable;  
 (may) not be burned safely because toxic gases are produced;  
 (may) not be bio-degradable/recyclable so will linger in landfill; [3 max]
- Accept other valid answers for both advantages and disadvantages.*  
*Each answer must be qualified.*



12. (a) rigid / rod-shaped; [1]
- (b) polar (group/molecule); [1]
- (c) (polarized) light shone through film of liquid crystal;  
 ability to transmit (polarized) light depends on orientation (of molecules);  
 orientation can be controlled by (small) voltage/potential difference (across small  
 film of material);  
*Accept current instead of voltage.*
- some areas can be dark/do not allow (polarized) light to pass **and** others  
 light/allow (polarized) light to pass; [3 max]
13. (a) research/technology development at 1–100 nm (range); [1]  
*Accept answers referring to a scale within the specified range.*
- (b) *Sides:*  
 (atoms arranged in) hexagons  
**and**  
*Ends:*  
 (atoms arranged in) pentagons (and hexagons); [1]
- (c) strong covalent/C–C bonding (in the walls of the nanotubes) / *OWTTE*; [1]
- (d) possible toxicity of small (airborne) particles;  
 explosive / small size/large surface area means dangerously fast reactions;  
 unknown health effects / immune system/allergy concerns;  
 uncertain impact on environment;  
 lack of public awareness about dangers;  
 increasing economic disparity between developed and developing nations; [2 max]  
*Accept other valid concerns.*

**Option D — Medicines and drugs**

14. (a) (i) range of dosages/concentrations of drug (able to treat disease successfully) staying within safety limit / between effective/ $ED_{50}$  and toxic levels/ $LD_{50}$ ; [1]  
*Do **not** accept definition of therapeutic index (ratio of  $LD_{50}/TD_{50}$  to  $ED_{50}$ ). Accept “lethal levels” for “toxic levels” even if laboratory animals are not referred to.*
- (ii) toxic levels are easily reached / effective dose not given for fear of reaching toxic level / close medical supervision required; [1]  
*Accept “lethal levels” for “toxic levels”.*
- (b) adverse effects of drug / physiological/psychological effect other than that for which the drug was prescribed / secondary (undesired) effects of drug / OWTTE; [1]
- (c) causes small bubbles (of gas) to coalesce into larger bubbles **and** be released as flatulence / anti-foaming agent / reduces bloating; [1]  
*Accept counteracts side-effects.*
15. (a) *Advantage:*  
relieves strong/severe pain / relieves pain caused by serious injury/cancer/surgery/heart attack / (intravenous so) faster acting;  
*Accept relieves anxiety / wide safety margin.*  
*Do **not** accept just “relieves pain”.*
- Disadvantages:*  
*Any two for [2 max] of:*  
(profound) tolerance develops;  
addictive/(physical) dependence/habit forming;  
causes drowsiness / mental clouding / depression/mood changes / constipation / loss of appetite / depression of the respiratory centre / nausea / suppresses cough reflex / pupil (of the eye) constriction / kidney/liver disorders; [3]  
*Do **not** accept other disadvantages, such as overdose and coma.*
- (b) morphine has (two) hydroxyl groups **and** diamorphine (heroin) has (two) ester groups; [1]  
*Accept alcohol or hydroxy for hydroxyl but **not** hydroxide.*

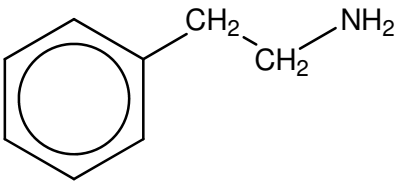
16. (a) (i)  $\text{CH}_3\text{CH}_2\text{OH}(\text{aq}) \rightarrow \text{CH}_3\text{CHO}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$ ; [1]  
 Accept equilibrium sign, e for  $\text{e}^-$  and different representations of organic compounds (such as  $\text{C}_2\text{H}_6\text{O}$  and  $\text{C}_2\text{H}_4\text{O}$ ).  
 Ignore state symbols.  
 Do **not** accept  $\text{CH}_3\text{CH}_2\text{OH} + [\text{O}] \rightarrow \text{CH}_3\text{CHO} + \text{H}_2\text{O}$  (since half-equation requested).

- (ii) (orange) dichromate(VI) ion/ $\text{Cr}_2\text{O}_7^{2-}$ /Cr(VI)/ $\text{Cr}^{6+}$  is reduced/converted to (green) chromium(III) ion/Cr(III)/ $\text{Cr}^{3+}$ ; [1]

- (b) absorption (of IR at  $2950\text{ cm}^{-1}$ ) by C–H bond;  
 (IR) absorption increases with/proportional to concentration / (IR) intensity compared to an empty/control cell; [2]  
 Accept area under peak/size of peak (on IR spectrum) can be used to measure ethanol concentration.

17. (a) (i) (releases adrenalin so) increased brain activity/alertness/concentration / reduction in sleepiness/restlessness/insomnia; [1]  
 Do **not** accept other effects, such as “increases heart rate” that are not related to the improvement of mental activity.

- (ii) anxiety / irritability / sleeplessness/insomnia / (weak) diuretic / increased blood pressure; [1]  
 Award [1 max] if the same effect is given in (i) and (ii).

- (b)  [1]  
 /  $\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{NH}_2$ ;  
 Accept Kekulé representation of benzene ring.

18. (a) (i) prevent the formation of bacterial cell walls / interfere with chemicals/enzyme/transpeptidase needed by bacteria to form normal cell walls / inhibits cross-links developing in bacterial cell walls; (osmosis) causes water to enter bacterial cell and cell bursts / cell wall weakens (making it more permeable to water) and bacterium bursts (and dies); [2]

- (ii) makes penicillin more effective / makes penicillin resistant to penicillinase (enzyme) / allows different methods of administration / penicillins can be made which are resistant to acid in the stomach; [1]

- (b) change cell membrane to prevent viruses entering/attaching to cell;  
 alter cell's genetic material so virus cannot use it to multiply;  
 inhibit enzymes involved in replication/reverse transcriptase / stop enzyme activity inside the cell (and prevent the viruses from multiplying);  
 prevent replicated virus leaving the cell;  
 initiates apoptosis/death of cells infected by viruses;  
 mimic guanosine/base-sugar monomer in DNA/RNA formation inhibiting enzymes involved in replication; [2 max]

**Option E — Environmental chemistry**

19. (a) (i) *Any one of:*

Gas	and	Source
methane/CH <sub>4</sub>		anaerobic decomposition of organic waste / bogs / marshes / animals / rice paddies / oil/gas fields;
nitrogen(I) oxide/ dinitrogen monoxide/N <sub>2</sub> O <i>Accept nitrous oxide.</i>		bacterial action / combustion of biomass / artificial fertilizers/use of nitrogen based fertilisers;
chlorofluorocarbons/CFCs		propellants in aerosol sprays/cans / (old) refrigerators / air conditioners / solvents / foaming agents/plastic foams / fire extinguishers;
ozone/O <sub>3</sub>		photochemical smog / interaction of sunlight with hydrocarbons and nitrogen oxides; <i>Accept electrical discharges.</i>
sulfur hexafluoride/SF <sub>6</sub>		gaseous dielectric medium in electrical industry / inert gas for casting magnesium / filling for double-glazed windows / electrical generators / insulator used in electrical industrial applications;
nitrogen trifluoride/NF <sub>3</sub>		(manufacture of) computer chips/circuits / (thin film) solar/photovoltaic cells / LCD televisions;

[1 max]

*Do not accept other gases such as SO<sub>x</sub> and NO<sub>x</sub> – generally reckoned to be insignificant.*

(ii) **Any two for [1] of:**

abundance/concentration (in atmosphere)  
strength/intensity/power of IR absorbance / ability to absorb heat radiation  
lifetime/duration / rate of depletion/decomposition in atmosphere;

[1]

(b)

Effect	and	Consequence
increased mean global temperature		thermal expansion of oceans / melting of polar ice-caps/glaciers / changes in weather patterns / changes in yield/distribution/viability of crops / changes in distribution of pests/disease-carrying organisms / changes food chain / endangers animals/plants/insects;
increase/decrease/change of local/regional temperature / climate change		melting of polar ice-caps/glaciers / changes in weather patterns / changes in yield/distribution/viability of crops / changes in distribution of pests/disease-carrying organisms / floods / droughts / destruction of habitat/infrastructure / loss of life / changes food chain / endangers animals/plants/insects;
(CO <sub>2</sub> in atmosphere) decreases pH/increases acidity of oceans		destruction of coral / changes/endangers animals/plants/insects/food chain;
<i>Accept thermal expansion of oceans</i>		<i>rising sea levels / flooding (of low lying areas) / destruction of habitat/infrastructure;</i>
<i>Accept melting of polar ice-caps/glaciers</i>		<i>rising sea levels / flooding (of low lying areas) / destruction of habitat/infrastructure;</i>
<i>Accept changes in precipitation / more extreme weather / more storms</i>		<i>floods / droughts / destruction of habitat/infrastructure / loss of life;</i>

[3 max]

Award [1 max] for three effects or consequences.

20. (a) *Formation:*  
 $O_2(g) \rightarrow 2O\cdot(g)$  **and** UV (light) /  $hf$  /  $h\nu$  ;  
 $O_2(g) + O\cdot(g) \rightarrow O_3(g)$  ;

*Depletion:*  
 $O_3(g) \rightarrow O_2(g) + O\cdot(g)$  **and** UV (light) /  $hf$  /  $h\nu$  ;  
 $O_3(g) + O\cdot(g) \rightarrow 2O_2(g)$  ;

*Accept  $O\cdot(g) + O\cdot(g) \rightarrow O_2(g)$  .*

*Only penalize missing "UV (light) /  $hf$  /  $h\nu$  " once.*

*Accept representation of radicals without  $\cdot$  if consistent throughout.*

[4]

- (b) chlorofluorocarbons/CFCs **and** propellants in aerosol sprays/cans / (old) refrigerators / air conditioners / solvents / foaming agents/plastic foams / fire extinguishers;  
*Accept specific examples (eg, Freon/dichlorodifluoromethane/CF<sub>2</sub>Cl<sub>2</sub> etc.).*

nitrogen(II) oxide/nitric oxide/nitrogen monoxide/NO **and** (high temperature reaction of N<sub>2</sub> with O<sub>2</sub> in) aircraft engines;  
*Accept NO<sub>x</sub>.*

*Award [1 max] for two correct pollutants even if sources are either incorrect or not given.*

[2]

21. (a) (i) amount/concentration of oxygen needed to decompose/oxidize organic/biological matter/waste in water; in a specified time/5 days / at a specified temperature/ 20°C ; [2]

(ii)

	<i>Nitrogen</i>	<i>Sulfur</i>
<i>Anaerobic</i>	NH <sub>3</sub> /ammonia / NH <sub>4</sub> <sup>+</sup> /ammonium / amine(s)	H <sub>2</sub> S/hydrogen sulfide/ S <sup>2-</sup> /sulfide
<i>Aerobic</i>	NO <sub>3</sub> <sup>-</sup> /nitrate	SO <sub>4</sub> <sup>2-</sup> /sulfate/sulfate(VI)

[2]

*Award [2] for 4 correct, [1] for 3 or 2 correct.*

- (b) *multi-stage distillation:*  
 sea water is heated/boiled;  
 passed into an evacuated chamber/low pressure chamber;  
 sea water boils/evaporates / (dissolved) solids left behind/in solution;  
 steam is condensed/cooled by (pipes containing) incoming sea/cold water;

**OR**

*reverse osmosis:*

- water moves from concentrated to dilute solution / water moves from lower [H<sub>2</sub>O] to higher [H<sub>2</sub>O];  
 high/~70 atm pressure;  
 through semi/selectively/partially permeable membrane;  
 (semi/selectively/partially permeable membrane) allows water but not ions/dissolved solids to pass through;

[3 max]

*Accept valid points communicated by means of diagrams.*

- (c) distance of facility from source of waste / transport costs;  
 cost/energy requirement to run the plant;  
 cost to build facility (to environmental/safety requirements);  
 possible use of generating electrical energy / supplying heating to homes;  
*Accept other reasonable **economic** arguments.*

[2 max]

**Option F — Food chemistry**

22. (a) glycerol / propan-1,2,3-triol; [1]  
*Accept minor errors in naming, such as propane-1,2,3-triol.*
- (b) (i) kink/shape of *cis*-isomer prevents molecules packing closely together / reduces area of close contact / *OWTTE*; [2]  
 so weaker intermolecular attractions/dispersion/London/van der Waals' forces;  
*Accept converse argument based on trans-isomer.*
- (ii) hard to metabolize / accumulates in fatty tissue / difficult to excrete; [2]  
 increases levels of LDL cholesterol / increases risk of heart disease;  
*Do **not** accept "increases level of bad cholesterol".*
- (iii) heat/140 – 225 °C / pressure; [2]  
*Accept any temperatures within the range.*
- (finely divided) metal catalyst / Ni / Pd / Pt / Cu / Zn;
23. (a) *Similarity:*  
 phenol/phenolic structure / hydroxyl group attached to phenyl/benzene ring;  
*Accept "all contain a benzene ring/phenyl (group) / all contain hydroxyl".*  
*Accept alcohol or hydroxy for hydroxyl, but **not** hydroxide.*
- Differences:*  
*Any two for [2 max] of:*  
 2-BHA and 3-BHA have ether group;  
 antioxidants (in data booklet) all have tertiary butyl group;  
 hydroxytyrosol and tyrosol have hydroxyl group (at end of carbon chain); [3]  
*Accept tyrosol and hydroxytyrosol have more than one hydroxyl group / OWTTE.*  
*Accept alcohol or hydroxy for hydroxyl but **not** hydroxide.*
- Accept correct formulas (eg, C<sub>6</sub>H<sub>5</sub>OH / –CH<sub>2</sub>CH<sub>2</sub>OH or C<sub>6</sub>H<sub>5</sub>– /–OH) instead of names.*
- (b) (i) inhibits formation of radicals / inhibits propagation of free-radical chain; [1]
- (ii) lowers LDL cholesterol;  
 lowers blood sugar levels;  
 lowers blood pressure;  
 reduces risk of heart disease;  
 inhibits cancer cell development / *OWTTE*; [2 max]  
*Do not accept "lowers bad cholesterol".*

24. (a) multiple conjugated/delocalized C=C/carbon to carbon double bonds;  
absorb light of certain wavelengths/frequencies in the visible region;  
transmit light of complementary colours (to those absorbed); [2 max]  
*Accept “reflect complementary colours”.*
- (b) light;  
higher/increased temperatures;  
metals / transition metal ions;  
hydroperoxides / peroxides; [2 max]  
*Accept acidity/low pH.*
25. (a) mechanical action/energy / mixing/beating / dispersing/mixing oil and water (is  
needed to make an emulsion); [1]  
*Accept whisking for mixing/beating.*
- (b) non-polar end/hydrophobic groups dissolve(s) in oil **and** polar end/hydrophilic  
groups dissolves in water/lemon juice;  
*Accept “interacts/bonds to” instead of “dissolves in”.*  
*Accept “soluble in both oil and water”.*
- emulsifier holds liquid droplets as a dispersed system / *OWTTE*; [2]



**Option G — Further organic chemistry**

26. (a) *Structure:*  
hexagon with all sides equal / regular hexagon;  
Accept "**two** of angles equal" OR "planar/flat" OR "hexagonal". (True for Kekulé structure!)

*Bonding:*

all (C–C) bonds equal strength / all (C–C) bonds have a strength between single and double bond / (C–C) bond orders all 1.5;

Accept "length" instead of "strength".

delocalized  $\pi$ -bond/electrons / resonance hybrid between two equivalent structures;

Accept all C-atoms have one  $\pi$ -bond and three  $\sigma$ -bonds /  $sp^2$  hybridization.

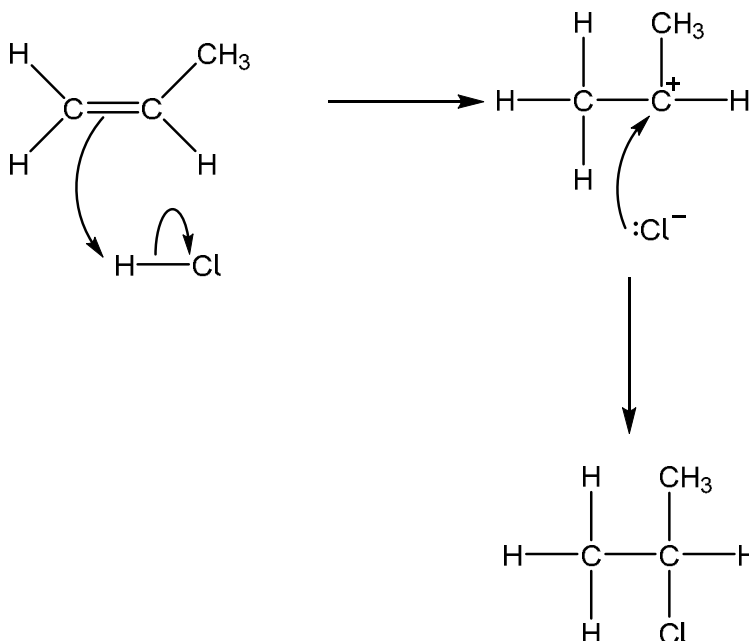
[3]

Give credit for correct responses given in the wrong section.

- (b) (enthalpy of) hydrogenation much less (negative/exothermic)/more endothermic than predicted (for alternate single and double C–C bonds);  
enthalpy of formation much less (positive/endothermic)/more exothermic than predicted (for alternate single and double C–C bonds);  
(enthalpy of) combustion much less (negative/exothermic)/more endothermic than predicted (for alternate single and double C–C bonds);  
Accept opposite statements for alternate single and double C–C bonds.

[1 max]

27. (a)



curly arrow going from C=C to H of HCl **and** curly arrow showing Cl<sup>-</sup> leaving;  
representation of carbocation (including position of positive charge);  
curly arrow going from lone pair/negative charge on Cl<sup>-</sup> to C<sup>+</sup>;  
formation of CH<sub>3</sub>CHClCH<sub>3</sub>;

Mechanisms that lead to the minor product could gain all but the last mark.

[4]

- (b) CH<sub>3</sub>CHBrCH<sub>3</sub>;  
Accept CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>Br if CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>Cl given in (a).

[1]

- (c) *Name:*  
 propan-1-ol/1-propanol / propan-2-ol/2-propanol;  
 Accept *n*-propanol and isopropanol/isopropyl alcohol.  
 Do **not** accept just propanol or the formula.

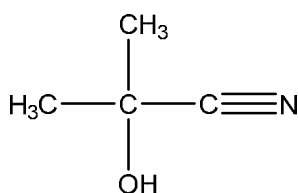
*Reagent:*  
 phosphoric acid/H<sub>3</sub>PO<sub>4</sub>;  
 Accept sulfuric acid/H<sub>2</sub>SO<sub>4</sub>.

*Type:*  
 dehydration / elimination;

[3]

28. (a) (nucleophilic) addition-elimination / condensation;

[1]



- (b) (i) / (CH<sub>3</sub>)<sub>2</sub>C(OH)CN;  
 Accept full or condensed structural formula.

[1]

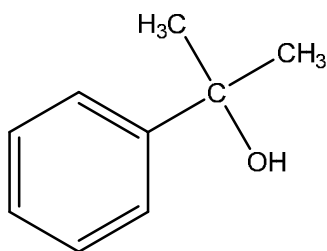
- (ii) *Propanone into B:*  
 hydrogen cyanide/HCN / cyanide ion/CN<sup>-</sup>/NaCN/KCN/NH<sub>4</sub>CN;

*B into C:*  
 hydrochloric acid/HCl;  
 Accept any acid/H<sup>+</sup>.

[2]

- (iii) hydroxyl group/OH is electron withdrawing/has –I (inductive) effect;  
 stabilizes the anion formed / weakens the O–H bond (in the –COOH  
 group);

[2]



- (c) (i) / C<sub>6</sub>H<sub>5</sub>C(CH<sub>3</sub>)<sub>2</sub>OH;  
 Accept full or condensed structural formula.

[1]

- (ii) magnesium/Mg **and** bromobenzene/C<sub>6</sub>H<sub>5</sub>Br;

[1]