

Markscheme

May 2015

Chemistry

Standard level

Paper 3

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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–H₃C) once only.

Option A — Modern analytical chemistry

1. (a) $E = \frac{hc}{\lambda}$ / $E = \alpha \frac{1}{\lambda}$ / energy inversely proportional to wavelength / the higher the energy the shorter the wavelength / OWTTE; [1]
Do not accept $E = hv/hf$.
- (b) visible/vis; [1]
Accept visible-ultra violet/vis-UV but not ultraviolet/UV.
- (c) (i) protons in water/carbohydrates/proteins/fats/lipids (can be detected by MRI);
protons in different environments produce different signals/chemical shifts /
protons in different environments absorb (radio waves) at different
frequencies / OWTTE; [2]
Accept "hydrogens" for protons in M1 and M2.
- (ii) (3D) image of organ (tissues) / can discriminate between tissues/
environments / can detect problems/abnormalities within body
(without surgery); [1]
Accept suitable examples (eg, may identify cancer/(brain) tumours/multiple
sclerosis/spinal infections/joint problems/hydrocephalus/osteomyelitis/bone
infections/(ischemic) stroke/blood vessel problems).
2. (a) (i) 56; [2]
 $C_4H_8^+$;
Penalize missing charge only once in (i) and (ii).
- (ii) $m/z = 27$: $C_2H_3^+/CH_2CH^+/CH_2=CH^+$ and $m/z = 29$: $C_2H_5^+/CH_3CH_2^+$; [1]
Penalize missing charge only once in (i) and (ii).
- (b) (i) (IR radiation is absorbed) as bond/C–C/C=C/C–H/molecule stretches / as
C–C–C/molecule bends;
increase in vibrational energy / excited to higher energy level;
change of dipole (moment)/polarity; [2 max]
Do not accept "molecule vibrates" alone.
- (ii) C=C/carbon–carbon double bond; [1]
Accept "alkenyl/alkene".
- (iii) $CH_3CH_2CH=CH_2$; [1]
Accept either a full or a condensed structural formula.

(c) (i) **C:** (mirror/beam splitter) splits beam into two beams;

D: provides a reference/control/baseline (for absorbance) / used to compare absorbance with the sample / allows measurement of absorbance without sample / determines background/solvent/air absorbance / reduces/eliminates systematic errors;

E: compares (the intensities of) sample and control/reference beams

OR

determines the absorbance (at particular frequencies);

Accept “(photomultiplier) converts photons/IR radiation into current”.

Accept “transmittance” for “absorbance” throughout.

Award **[1 max]** if names given for **C:** mirror/beam splitter, **D:** control/reference/solvent **and E:** detector/photomultiplier.

[3]

(ii) (region where) bond bending occurs;

Accept “bending of molecule”.

compound can be identified by distinctive/characteristic/complex pattern / (region of spectrum) used for comparison purposes with spectral libraries / OWTTE;

[2]

3.

	Partition or adsorption?	Mobile phase
Paper	partition	solvent/eluent
Column	adsorption	solvent/eluent;

Accept appropriate specific examples for solvents (common examples might include water, ethanol, ethanoic acid, propanone or just alcohol).

Accept “absorption” instead of “adsorption” as it is given in the column heading.

Clarification: Award M1 if all cells in the “partition or absorption” and the “mobile phase” columns are correct.

	Stationary phase
Paper	water (in cellulose fibres of paper);

Do not accept just “paper” or “liquid”.

Clarification: Award M2 is for the “stationary phase” in paper chromatography.

	Stationary phase
Column	silica(gel)/SiO ₂ / alumina/Al ₂ O ₃ ;

Accept “solid used to pack the column”.

Clarification: Award M3 is for the “stationary phase” in column chromatography.

[3]

Option B — Human biochemistry

4. (a) (i) NH_2 /amino group at C2 (while C of COOH /carboxyl/carboxylic acid is C1) / *OWTTE*; [1]
Accept *amine* for NH_2 .
- (ii) arginine/Arg; [1]
- (iii) **Any two** from the following for [1 max]:
alanine/Ala;
isoleucine/Ile;
leucine/Leu;
methionine/Met;
valine/Val;
phenylalanine/Phe;
tryptophan/Trp; [1]
Accept "*proline/Pro*".
- (iv)
$$\begin{array}{c} \text{H}_3\text{N}^+ - \text{CH} - \text{COOH} \\ | \\ \text{H}_3\text{C} - \text{CH} - \text{CH}_3 \end{array} \quad \text{and} \quad \begin{array}{c} \text{H}_3\text{N}^+ - \text{CH} - \text{COO}^- \\ | \\ \text{H}_3\text{C} - \text{CH} - \text{CH}_3 \end{array};$$
 [1]
- Structural formulas of cation and zwitterion are required for the mark.*
- Accept structural formula of zwitterion alone (as it's the dominant form).*
Accept structural formula of cation alone (though lower in concentration than zwitterion based on equilibrium and pH calculations).
Accept full or condensed structural formula(s).
- (b) Asp–Gln–His;
Asp–His–Gln;
Gln–Asp–His;
Gln–His–Asp;
His–Asp–Gln;
His–Gln–Asp; [2]
Award [2] for all six correct, [1] for five, four or three.
- (c) gives strength to tendons/bones/ligament/skin/cornea/cartilage/blood vessels / connective tissue; [1]
Accept "*elasticity*" for "*strength*" but do not accept answers such as "*protects bones*" etc.
Accept just "*structural*".

5. (a) *Similarity in structure:*
both are (tri)esters / both made from glycerol/propane-1,2,3-triol/
HOCH₂CH(OH)CH₂OH;
- Difference in structure:*
phospholipids have phosphate group/phosphorus **and** fats are triglycerides/made
from three fatty/carboxylic acids / one fatty/carboxylic acid (in fat) replaced by
phosphate in phospholipid;
- Difference in polarity:*
phospholipids are more polar / phospholipids have hydrophilic
(heads/section/part/end) / fats are less polar/non-polar / fats are hydrophobic ; [3]
- (b) (i) (two) more carbon–carbon double bonds/alkenyl groups in vitamin D;
Accept alkene for alkenyl.
extra hexagon/6-membered ring in cholesterol / more fused rings in
cholesterol / four fused rings in cholesterol **and** two fused rings in
vitamin D; [1 max]
*Accept “(some) conjugation in vitamin D / (some) alternating C=C and C–C
bonds in vitamin D”.*
*Accept “cholesterol has a steroid backbone/structure but vitamin D does
not”.*
- (ii) *Composition:*
HDL has more protein **and** less cholesterol/fat/lipid (and vice-versa);
*Accept “HDL has more protein **and** LDL has more cholesterol (and
vice-versa)”.*
*Accept “HDL has higher phospholipid content compared to LDL (and
vice-versa)”.*
*Accept “HDL particles are smaller than LDL particles (and vice-versa)” but
do not penalize if “molecules” are used instead of “particles”.*
- One effect on health:*
cardiovascular problems/increased risk of heart
disease/obesity/atherosclerosis/blocked arteries from high ratio of LDL
to HDL; [2]
Accept “from (high) LDL” instead of “from high ratio of LDL to HDL”.
Accept “can result in a heart attack/stroke from high ratio of LDL to HDL”.
Accept “large amounts of HDL in blood correlate with good health / OWTTE”.
- Reference must be made to LDL or HDL.*
- (iii) calcium/Ca / phosphorus/P; [1]

6. (a) structure/function similar to testosterone;
causes increased rate of protein synthesis/tissue/muscle building/increase in muscle mass / OWTTE; [2]
Accept “anabolic” for M2.

- (b) (i) *Similarity in structure:*
(both have) carbon-carbon double bond/C=C (group)
Accept “alkenyl/alkene” for C=C.

OR

(both have) carbonyl/C=O (group);
Accept “ketone/alkanone” for carbonyl.

Difference in structure:
(G has) alkynyl/C≡C
Accept “alkyne” for C≡C.

OR

(G has) hydroxyl/OH (group)
Accept “alcohol/hydroxy” but not hydroxide for OH.

OR

(G has) one less carbonyl/C=O (group); [2]
Accept “ketone/alkanone” for carbonyl.

Answers must be in terms of functional groups only for this question.

- (ii) mimics the action of progesterone in pregnancy / fools reproductive system that body is pregnant;
prevents release of egg / no ovulation;
prevents release of LH/FSH;
prevents sperm from reaching egg / thickens cervical mucus; [2 max]

Option C — Chemistry in industry and technology

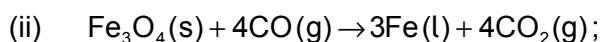
7. (a) (i) $+\frac{8}{3} / +2\frac{2}{3}$;

Accept +2.7 but not +3.

+2 **and** +3 / contains two (or more) iron ions with different oxidation states / contains Fe²⁺ **and** Fe³⁺; [2]

Accept II and III oxidation number notation for oxidation states but not 2+ and 3+ unless ions are referred to explicitly.

Accept "contains different iron compounds/FeO **and** Fe₂O₃".



Accept " $\text{Fe}_3\text{O}_4(\text{s}) + \text{CO}(\text{g}) \rightarrow 3\text{FeO}(\text{s}) + \text{CO}_2(\text{g})$ **and**

$\text{FeO}(\text{s}) + \text{CO}(\text{g}) \rightarrow \text{Fe}(\text{l}) + \text{CO}_2(\text{g})$ ".

Ignore state symbols.

(iii) Al is more reactive than Fe / Al is higher than Fe in the reactivity series / Al is a stronger reducing agent / it is harder to reduce aluminium ores compared to iron ores / Fe³⁺/Fe²⁺ is a stronger oxidizing agent / Al³⁺ has a very negative E° value; [1]

(b) (heat to a) high temperature/approximately 1000 °C **and** cool (slowly);

Accept any temperature greater than or equal to 500 °C but do not award mark if there is any reference to "cooling rapidly".

(makes steel) more malleable / more ductile / less brittle; [2]

Accept "(makes steel) softer".

8. (a)

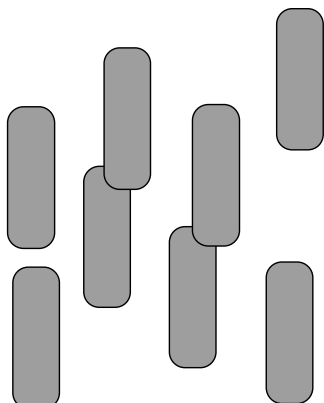


diagram should have molecules with a parallel alignment in any direction (not just upwards);

diagram should have molecules in an irregular arrangement in space; [2]

Ignore relative separation between molecules.

Award [1 max] if number of molecules < 7.

Award [1 max] if stated "molecules align parallel to each other but with an irregular arrangement in space / OWTTE" but with no diagram drawn.

Allow the representation of molecules by lines.

- (b) (i) polar/dipole moment due to the presence of C≡N (bond) / difference in electronegativity between C and N; [1]
- (ii) prevents close packing of molecules / *OWTTE*; makes the molecule (longer and) more rod-like; [1 max]
- (iii) molecules become more ordered / molecules unable to change orientation (as they approach fixed arrangement of solid state) / molecules move slower / viscosity (of medium) increases (so LCD response time increases); [1]
9. (a) physical; atoms placed in specific positions; using a scanning tunnelling microscope/STM / atomic/scanning force microscope/AFM/SFM; [2 max]
Accept "using a scanning probe/device/instrument".
- (b) any value in the range 10^{-9} – 10^{-8} (m); [1]
10. (a) (i) alkenyl/C=C **and** phenyl/–C₆H₅; [1]
Accept alkene and benzene ring/aromatic ring/arene but not benzene.
- (ii) pentane/volatile hydrocarbon added (during polymerization process); heating causes pentane/volatile hydrocarbon to evaporate/vaporize/produce bubbles of gas (expanding the polystyrene); [2]
Accept other suitable identified blowing agents such as carbon dioxide.
- (b) *Advantages:*
Any two for [2 max]:
low/reduced density;
Accept "small mass".
Do not accept "light".
- can be shaped (around object);
good shock absorber;
insulator;
- Disadvantage:*
Award [1] for disadvantage:
- disposal takes up a lot of space (in landfill); [3]
Accept "non-biodegradable/polluting/hazardous to wildlife".

Option D — Medicines and drugs

11. (a) (i) increased heart rate;
increased blood pressure / constricted blood vessels;
reduced urine output / antidiuretic;
increased concentration / alertness / stimulating effect / reduced anxiety /
relaxation / enhanced memory;
reduced appetite;
pain-killing effect; [2 max]
Allow anti-depressant.
Do not accept effects related to smoking and not nicotine.
- (ii) (smoke contains other) toxins/tar;
(increased risk of) (lung/mouth/throat) cancer / carcinogenic / heart disease
/ emphysema / bronchial disorders; [2]
- (b) (i) lone pair/non-bonding/electron pair on nitrogen (atom)/amino (group);
Accept "amine" for "amino".
reacts with H^+ / donates lone/non-bonding/electron pair to H^+ / acts as
Lewis base; [2]
Accept "proton/ H^+ acceptor".
Do not accept "produces OH^- " for M2.
Award [1 max] for "contains amino/amine".
- (ii) dissolves in aqueous medium in body / OWTTE; [1]
Accept "(passes through) lungs/cell membrane".
Do not accept "inhalation".
- (c) (i) the body's reaction to a drug is reduced (when the drug is used repeatedly) /
OWTTE; [1]
*Accept "more of the drug needs to be taken to achieve the original/same
effect".*
- (ii) transdermal / patches / absorbed through skin;
(per)oral / gum / polacrilex / tablets/pills / lozenges / pastille;
(intra)nasal (spray); [2 max]
Accept "injection" (if NicVAX mentioned only).
Accept "inhalers".
Do not accept "electronic/e-cigarettes".
12. (a) nucleic acid / DNA/deoxyribonucleic acid / RNA/ribonucleic acid;
protein; [2]
*Accept "(surrounded by coat of protein units called) capsomers / (surrounded by
protective protein shell called a) capsid".*
Award [2] for "nucleoprotein".
- (b) alter cell's genetic material;
(changes cell membrane so that it) inhibits virus entry/binding to cell;
prevents virus from leaving cell (after reproduction);
becomes part of DNA of virus / alters virus / blocks enzyme (polymerase) which
builds DNA;
prevents virus from using cell to multiply/reproduce/replicate; [2 max]
Do not accept "blocks enzyme activity within host cell / OWTTE".

- (c) HIV mutates (rapidly) / OWTTE;
Do not accept "AIDS mutates" without mention of the virus.

HIV destroys (T-)helper cells/white blood cells/lymphocytes / HIV attacks immune system; [2]

Penalize the use of "AIDS" for "HIV" once only.

Do not accept general answers based on "cost of drugs" or "cost of development".

13. (a) Morphine: D;
Aspirin: A;
Codeine: C; [2]
Award [2] for all three correct, [1] for two correct.

- (b) Similarities:
Award [1 max] for any two:
benzene ring/aromatic ring/ $-C_6H_2$;
Accept "phenyl" or "arene" but not C_6H_5- or benzene/ C_6H_6 .

(tertiary) amino/ $-NRR'/NRR'R''$;
Accept "(tertiary) amine".

carbon-carbon double bond/ $C=C$;
Accept "alkene" or "alkenyl".

ether/ $C-O-C$;

Accept "both have the same ring structure / OWTTE".

Difference:
ester/ CH_3COO in diamorphine/heroin **and** hydroxyl/ OH in morphine; [2]
Accept "ethanoate" for ester.
Accept "alcohol" or "hydroxy" for hydroxyl but not hydroxide.

Option E — Environmental chemistry

14. (a) Q;

waste needs oxygen to decompose/decay/be broken down (and so there is a decrease in oxygen concentration after the factory) / waste increases BOD/biochemical/biological oxygen demand; [2]

(b) (i) nitrate **and** phosphate (ions); [1]
*Accept names including the oxidation number only if the number is correct ie nitrate(V) **and** phosphate(III).*
Accept nitrates and phosphates.

(ii) increased growth of plants/algae / algal blooms / eutrophication; (aerobic bacteria) decompose the dead plants; algae block sunlight disrupting photosynthesis (of plants below the surface of the water); [2 max]

(c) heat / thermal pollution / increase in temperature (of water); [1]

15. (a) (i) $\left(\lambda = \frac{3.0 \times 10^8}{3.5 \times 10^{13}} \right) 8.6 \times 10^{-6} \text{ (m)};$ [1]

(ii) IR/infrared; [1]

(b) N₂O; [1]

(c) CO₂ has a (much) greater relative contribution (to increased global warming compared to N₂O) since it is more abundant;

CO₂ is less effective at absorbing IR/radiation/heat / greenhouse factor/greenhouse warming potential/GWP of CO₂ is (considerably) less than N₂O; [2]
Accept "CO₂ absorbs less IR/radiation/heat (or vice versa for N₂O)".
Accept converse arguments.

(d) changes in the yield/distribution of crops / OWTTE; droughts / water shortages (in some areas); flooding; deserts increase in size / OWTTE; decreasing (fertile) land area due to rising sea levels; pests/insects/disease carrying organisms multiply/spread over larger areas; [2 max]

16. (a) harvesting/removal (of crops) / irrigation (removes soluble nutrients) / acidification through addition of fertilizer;
Do not accept "salinization".
- (nutrients replaced by) compost/(artificial) fertilizer / crop rotation; [2]
Do not accept "humus".
- (b) has many (polar) hydroxyl/OH/carboxyl/COOH (groups);
Accept "alcohol/hydroxy" for hydroxyl and "carboxylic acid" for carboxyl but not hydroxide for hydroxyl.
- can form (many) hydrogen bonds (with water molecules in the soil); [2]
- (c) transistors/capacitors / electronics / coolants / plasticizers / lubricants / insulating liquids / hydraulic systems / mining equipment; [1]
Accept specific examples such as refrigerators.
- (d) reduces soil biodiversity / disrupts balance of microorganisms in soil; acidification of soil;
disrupts food webs/cycles;
stimulates growth of harmful bacteria; [2 max]
Accept "unbalanced fertilizer use leads to nutrient deficiencies".

Option F — Food chemistry

17. (a) *Food:*
substance (intended) for consumption;
Nutrient:
obtained from food **and** used by body for metabolism/to provide energy/regulate growth/repair body tissues; [2]

(b) (i) *Similarity:*
both are (tri)esters / both made from glycerol/propane-1,2,3-triol/ $\text{HOCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$ / both are triglycerides;
Difference:
unsaturated fats have $\text{C}=\text{C}$ /carbon-carbon double bond / saturated fats have no $\text{C}=\text{C}$ /carbon-carbon double bonds; [2]

(ii) *trans* fat;
greater RMM/relative molecular mass / larger number of electrons / longer carbon/hydrophobic chains / *OWTTE*; [1 max]

(c)

Nutrient	Purpose
proteins and	provide amino acids for protein/enzyme production / growth / repair / hormone synthesis;
carbohydrates and	energy (source);
vitamins and	to protect health / for (normal) growth / for metabolism / co-factor / prosthetic group / for healthy vision/skin / for (normal) cell function / prevents specific diseases;
minerals and	to protect health / (regulate) growth / for metabolism / for nerve functioning / for fluid balance / oxygen transport / for muscle contraction / for healthy bones/teeth/immune system / prevent blood clotting / regulates blood pressure / for acid-base balance / for (normal) cell function;

[2 max]

Award [1] for two correct nutrients without correct purpose.

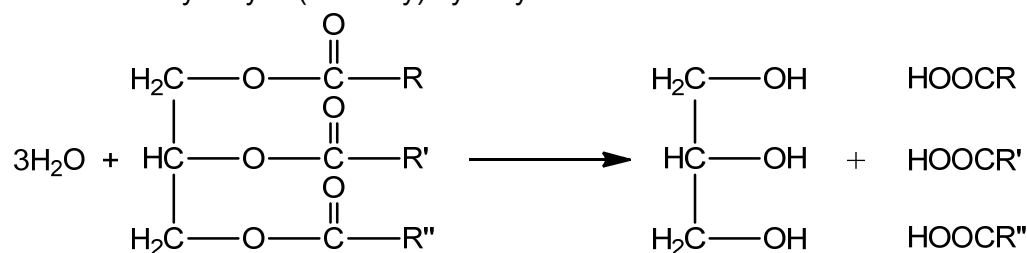
18. (a) **Shelf life:**
time after which food no longer maintains the expected quality/flavour/smell/
texture/appearance (desired by consumer);

"Best-before" date:

usually (well) within the expected shelf life period (to cover retailers/
manufacturers from litigation) / best-before date is less than shelf life / OWTTE;

[2]

- (b) **Reaction 1: hydrolytic (rancidity)/hydrolysis and**



OR

hydrolytic (rancidity) **and** hydrolysis of ester links/breaking down of lipid/fat to
glycerol/propane-1,2,3-triol **and** fatty/carboxylic acids;

Reaction 2: oxidative (rancidity)/oxidation and

addition of O₂ across C=C/carbon-carbon double bonds / oxidation of
C=C/carbon-carbon double bonds;

[2]

Do not penalize omission of "carbon-carbon" if already penalized in F.17(b)(i).

Award [1 max] for "hydrolytic (rancidity)/hydrolysis" and "oxidative
(rancidity)/oxidation" only.

- (c) (i) **vitamin C:**
reduces risk of cancer/heart disease/stroke/scurvy/scorbutus/gum
disease/neurological disorders / important for production of
hormones/collagen / helps cure infections/skin problems / helps heal
wounds / reduces the harmful effects of stress / helps lower cholesterol /
improves blood flow / regulates (blood) sugar levels in diabetics / helps
control allergies / helps prevent cataracts ;
Accept "used to prevent/treat/reduce the severity of colds".

β-carotene:

precursor to vitamin A / reduces risk of cancer/heart disease/cataracts/
dementia / helps to treat AIDS/alcoholism/Alzheimer's/depression/epilepsy
/headache/heartburn/high blood pressure/infertility/Parkinson's disease/
rheumatoid arthritis/schizophrenia/skin disorders;

[2]

Do not accept same answer for both.

- (ii) (perceived to be) less healthy/safe / could cause harmful side
effects/allergies;
need regulation;
safe labelling/use of additives is difficult internationally/in
underdeveloped/developing countries;
may interfere with auto-oxidation;

[2 max]

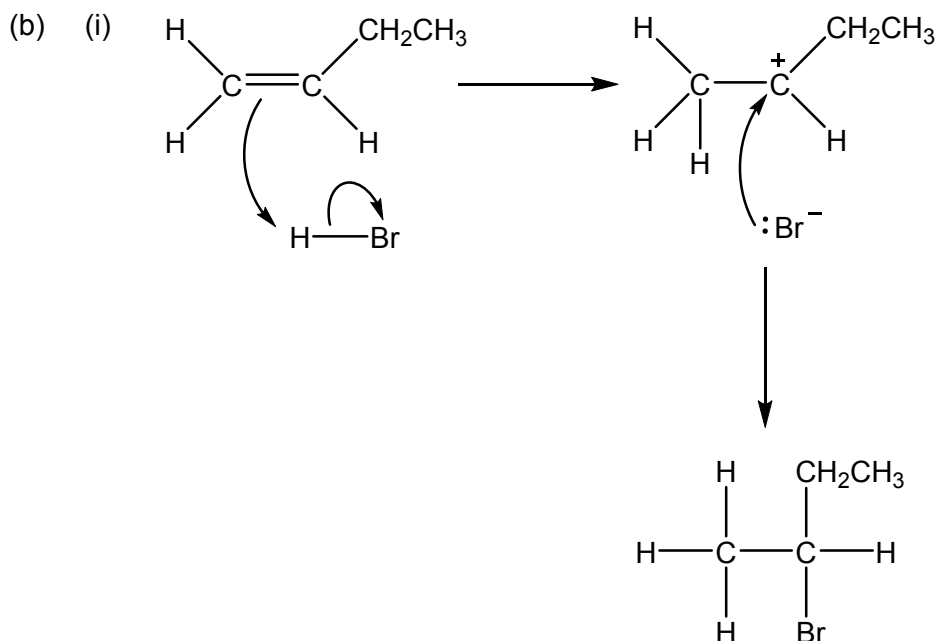
19. (a) *When shaken together:*
(cloudy) emulsion (of oil in vinegar) / form an apparent mixture / form a cloudy
(turbid) mixture / OWTTE;
Accept "oil droplets in vinegar".
- After standing:*
separates into two layers; [2]
Ignore which layer is on top.
- (b) (i) helps with the formation of emulsions/foams / acts as the interface (surface)
between phases (in the dispersed system) / is soluble in fat and water /
stabilizes a blend/mixture/combination of two immiscible liquids; [1]
- (ii) charged nitrogen/ammonium/oxygen/phosphate/ionic/polar/hydrophilic
head/end/part interacts with/dissolves in aqueous layer/vinegar;
hydrocarbon/non-polar/hydrophobic end/tail/part interacts with/dissolves in
oil; [2]
*Award [1 max] for stating "has both polar/ionic/hydrophilic and
non-polar/hydrophobic/hydrocarbon tail/ends/parts".*

Option G — Further organic chemistry

20. (a) *Reagent:*
HBr/hydrogen bromide;

Type of reaction:
electrophilic addition;

[2]



curly arrow going from C=C to H of HBr **and** curly arrow showing Br leaving;
representation of carbocation;
curly arrow going from lone pair/negative charge on Br⁻ to C⁺;

[3]

- (ii) (intermediate) $\text{CH}_3\text{CH}_2^+\text{CHCH}_3$ is more stable than $\text{CH}_3\text{CH}_2\text{CH}_2^+\text{CH}_2$;
Accept "secondary carbocation more stable than primary carbocation".

electron releasing/inductive effect of $-\text{CH}_2\text{CH}_3$ plus $-\text{CH}_3 > -\text{CH}_2\text{CH}_2\text{CH}_3$ /
two electron releasing R groups on secondary carbocation compared to one
on the primary carbocation;
*Comparison required for M2 but accept "electron releasing/inductive effect of
two R groups spreads positive charge more (so more stable)".*

[2]

- (c) *Equation:*
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{CHCH}_2 + \text{H}_2\text{O}$;
Accept $\text{C}_4\text{H}_9\text{OH} \rightarrow \text{C}_4\text{H}_8 + \text{H}_2\text{O}$.

Conditions:

170°C/180°C /heat **and** concentrated phosphoric acid/ H_3PO_4 ;

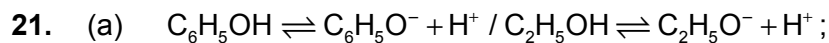
Accept concentrated sulfuric acid/ H_2SO_4 instead of concentrated phosphoric acid/ H_3PO_4 .

Accept temperatures in the range 160–190°C.

[2]

- (d) $\text{CH}_3\text{CHICHICH}_3$;
 $\text{CH}_3\text{CH}_2\text{CHICH}_2\text{I}$;
Accept either full or condensed structural formulas.

[2]



Accept corresponding equations with water.

Accept a single arrow.

EITHER

positive inductive effect (of alkyl group) in ethanol;

strengthens OH bond / makes release of H^+ difficult;

Accept converse argument for phenol.

OR

lone/non-bonding pair on oxygen/negative charge on phenoxide anion/ $C_6H_5O^-$

can delocalize/spread round benzene ring;

so charge density decreases / phenoxide ion is stabilized;

Accept converse argument for ethanol.

[3]

M2 can be gained from suitably labelled diagram.

- (b) nitro group electron withdrawing / conjugation extends to nitro group;
Accept "nitro group is ring deactivating/decreases electron density around ring".

electrons pulled away from ring/O–H bond/ O^- in anion;

so H^+ leaves (more) easily / more protons lost meaning 4-nitrophenol more acidic

/ O–H bond is weaker (in 4-nitrophenol) so 4-nitrophenol more acidic / more

stable anion so 4-nitrophenol more acidic;

Award [1 max] for stating that "4-nitrophenol is more acidic" if no other marks scored.

[3]

22. (a) *Reagent:*
Mg/magnesium;

Condition:

anhydrous/dry / ether/ethoxyethane/non-polar solvent;

Accept "heat".

[2]

- (b) CH_3CHO /ethanal **and** H_2O /water/ H_3O^+ /(dilute) acid;

[1]