M14/4/CHEMI/HP3/ENG/TZ2/XX/M

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MARKSCHEME

May 2014

CHEMISTRY

Higher Level

Paper 3

26 pages

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 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

Penalize incorrect bond linkages (eg, CH_2–HO instead of CH_2–OH) and/or missing hydrogens once only in option at first occurrence.

1. (a)

Purpose	***Analytical Technique***
Determining the level of ethanol in the breath of a driver of a vehicle	infrared (spectroscopy)/IR *Allow gas (liquid) chromatography/GLC.*
Determining the concentration of chromium in seawater	atomic absorption (spectroscopy)/AA/AAS
Body scanning to diagnose the autoimmune disease, multiple sclerosis	(^{1}H/proton) nuclear magnetic resonance/NMR / magnetic resonance imaging/MRI *Allow PET.*
Testing for the presence volatile performance of volatile performance-enhancing drugs, such as nandrolone	gas-liquid chromatography/GLC / gas chromatography-mass spectrometry/GCMS *Allow HPLC / IR (spectroscopy).*

[2]

*Award **[2]** for all four correct, **[1]** for two or three correct.*

(b) *Absorption spectra*:
(when radiation is passed through sample) atom/ion/molecule becomes excited / electrons raised to higher energy level/state / *OWTTE*;
only specific frequencies/wavelengths absorbed / black lines on a coloured background / spectrum shows where absorption happens, such as dips (in the IR spectrum) / *OWTTE*;

Emission spectra:
(energy given out by) excited atom/ion/molecule moves to lower energy state / excited electrons move to lower energy level/ground state / *OWTTE*;
colours same as those missing from absorption spectra / coloured lines on black background / only specific frequencies/wavelengths emitted / *OWTTE*; ***[4]***
Difference may also be shown by two different representations of spectra.

2. (a) (i)

Compound	***R_f value***
A	0.28
B	0.81

; ***[1]***

*Award **[1]** for both correct.*

(ii) B is more soluble in solvent/mobile phase / B is less polar than A / B is less strongly adsorbed onto stationary phase; ***[1]***
Accept B is non-polar.
Do not allow "greater attraction/affinity to solvent" without reference to solubility.

(b) nitrogen/helium/inert gas mobile phase;
Do not accept just gas.

high boiling point liquid/(long-chain) alkane/polysiloxane stationary phase (on a solid support);
sample injected into mobile phase;
sample/liquids vaporized (in oven/at high temperature);
sample carried by inert gas through column;
detector at end of column;
change of detector signal with time recorded;
components separated by partition between alkane and gas;
liquids/components have different retention times/move through tube at different speeds / speed of separation is temperature dependent;
area under peak proportional to quantity/amount of component present (in mixture); ***[4 max]***

3. (a) *I*: O–H **and** *II*: C=O; ***[1]***
Do not allow CO for C=O.
Allow OH for O–H.

(b) three hydrogens in same (chemical) environment / CH_3/methyl (group); ***[1]***

(c) *Award **[2]** for all three correct, **[1]** for any two correct.*
m/z = 45 :
$COOH^+$ /CO_2H^+ / $C_2H_5O^+$;

m/z = 17 :
OH^+ ;

m/z = 15 :
CH_3^+ ; ***[2]***
Penalize missing + once only.

(d) $CH_3CH(OH)COOH$ / $CH_3CH(OH)CO_2H$; ***[1]***
Allow full or condensed structural formula.

(e) $CH_2(OH)CH_2COOH$ / $HO(CH_2)_2CO_2H$; ***[1]***
Allow full or condensed structural formula.

(f) (i) 102; ***[1]***

(ii)

Ratio under each peak	***Range of chemical shift values / ppm***	***Splitting pattern***
3	0.9–1.0 (CH_3)	(3H) triplet
2	2.0–2.5 (CH_2)	(2H) quartet
2	3.8–4.1 (OCH_2)	(2H) quartet
3	0.9–1.0 (CH_3)	(3H) triplet

[3 max]

*Award **[3 max]** for four correct rows.*
*Award **[2 max]** for any two or three correct rows and **[1 max]** for any correct row.*

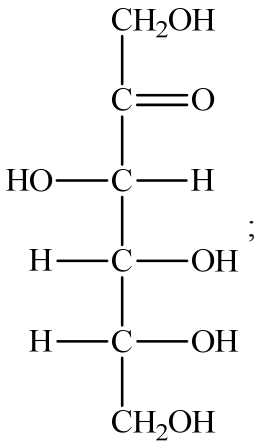
4. (a) I;
more conjugation/delocalization of electrons / more alternating C–C and C=C
and
the less energy required to excite electrons / absorbs in visible region/at longer wavelength/lower frequency; ***[2]***

(b) absorbs red/orange/yellow/long wavelength visible light (hence appears as the complementary colour); ***[1]***

Option B — Human biochemistry

Penalize incorrect bond linkages (eg CH_2–HO instead of CH_2–OH) and/or missing hydrogens once only in option at first occurrence.

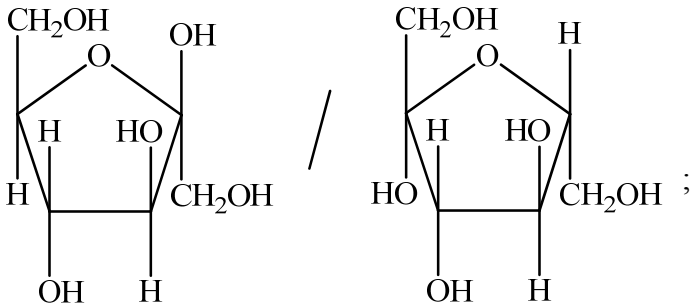
5. (a) (source of) energy; ***[1]***

(b) (i) 

;

[1]

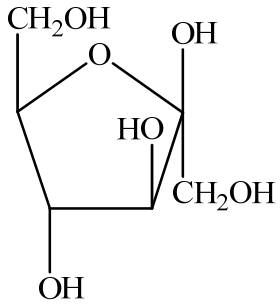
Accept any six-carbon linear structure in which the second carbon is a carbonyl and there is one OH on all other carbons.

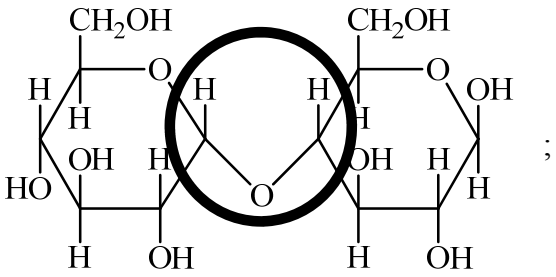
(ii) 

;

[1]

Correct orientation of groups is required.
Allow Haworth projection, ie,



(c) (i) 

;

[1]

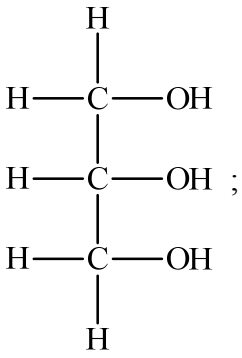
Circle must include the two carbon atoms.

(ii) α-glucose; ***[1]***

Allow glucose.

(iii) lactose is made up of galactose and glucose while maltose is made up of two glucose molecules;
positions of OH groups on far left and far right carbons are interchanged / *OWTTE*;
lactose contains a beta (1,4 glycosidic) link while maltose contains an alpha (1,4 glycosidic) link;
position of H on left-side of 1,4 glycosidic link differs in both maltose and lactose / *OWTTE*; ***[2 max]***

6. (a) (i)



; ***[1]***

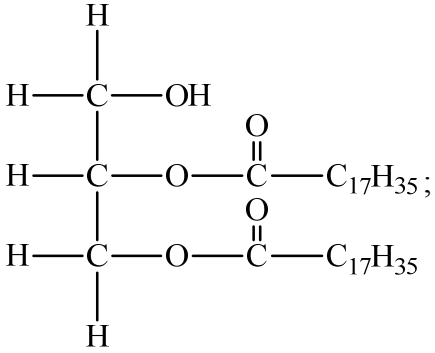
Accept any correct representation.

(ii) *Name of functional group of triglyceride*:
ester
Allow triester.
Do not allow –COO–.

and

Other product formed:
water/H_2O; ***[1]***

(b) *Structure of diglyceride, distearin*:



;

Accept a structure with OH in middle also.

Name of other product:
stearic acid/octadecanoic acid / stearate/octadecanoate; ***[2]***
Name required.
Do not allow stearin.

7. (a) clenbuterol does not contain 4-ring structure / steroid backbone / three six-membered rings **and** a five-membered ring; ***[1]***
Allow "does not contain steroid structure".

(b) testosterone and progesterone both contain an alkene/C=C **and** a C=O/ carbonyl;
Allow ketone instead of carbonyl.
Ignore any reference to methyl groups.

OH/hydroxyl present (only) in testosterone; ***[2]***
Do not allow hydroxide.
Allow alcohol/hydroxy.

8. (a) DNA made up of two polynucleotides that join to form a spiral/double helix;
two strands of nucleic acid interaction through hydrogen bonding network between bases / polynucleotides linked by hydrogen bonds between bases;
alternating phosphate and sugar groups form the backbones with bases on the sugar;
thymine/T bonds to adenine/A **and** cytosine/C bonds to guanine/G;
double helix stabilized by dipole-dipole **and** vdW interactions between base pairs; ***[3 max]***

(importance of hydrogen bonding is that) hydrogen bonds between bases can be broken allowing copying of DNA / *OWTTE*; ***[1]***

(b) sample of DNA (got from bodily fluid) cut into small pieces using restriction enzymes;
polymerase chain reaction/PCR to amplify regions in DNA by making multiple copies;
DNA fragments separated and detected using gel electrophoresis;
fragments made radioactive using ^{32}P;
X-ray image obtained showing pattern unique to individual; ***[3 max]***

9. (a) (hemoglobin large protein molecule with) iron(II) held by four (nitrogen) ligands/coordinate/dative bonds (to form heme);
porphyrin/heme encapsulated in protein/polypeptide unit;
hemoglobin comprises four/several/more than one of these (protein/polypeptide) units; ***[2 max]***

(b) (during respiration) oxygen bonds (temporarily) to iron (while hemoglobin travels through bloodstream releasing oxygen molecule when and where needed);
decreasing pH causes change in polypeptide releasing the oxygen;
each hemoglobin bonds to four oxygens;
iron stays in +2 oxidation state; ***[2 max]***

Option C — Chemistry in industry and technology

10. (a) electrolysis of aqueous/solution of sodium chloride/NaCl; ***[1]***
Accept brine.

(b) *Positive electrode (anode)*:
$2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$;

Negative electrode (cathode):
$2H^+(aq) + 2e^- \rightarrow H_2(g) / 2H_2O(l) + 2e^- \rightarrow 2OH^-(aq) + H_2(g)$; ***[2]***
Ignore state symbols.
Allow e instead of e^-.

(c) *Process*:
membrane cells;

Reason:
less polluting / new membranes developed / demand for purer products / greater efficiency; ***[2]***

11. (a) (i) *Lead-acid*:
Positive electrode (cathode):
$PbO_2(s) + SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$ /
$PbO_2(s) + HSO_4^-(aq) + 3H^+(aq) + 2e^- \rightarrow PbSO_4(s) + 2H_2O(l)$;

Negative electrode (anode):
$Pb(s) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + 2e^-$ /
$Pb(s) + HSO_4^-(aq) \rightarrow PbSO_4(s) + 2e^- + H^+(aq)$; ***[2]***
Allow e for e^- throughout.
Ignore state symbols.
*Award **[1 max]** if correct equations are given but at the wrong electrodes.*

(ii) *NiCad*:
Positive electrode (cathode):
$NiO(OH)(s) + H_2O(l) + e^- \rightarrow Ni(OH)_2(s) + OH^-(aq)$;

Negative electrode (anode):
$Cd(s) + 2OH^-(aq) \rightarrow Cd(OH)_2(s) + 2e^-$; ***[2]***
Allow e for e^- throughout.
Ignore state symbols.
*Award **[1 max]** if correct equations are given but at the wrong electrodes.*

(b) *Similarity*:
(both) convert chemical energy to electrical energy / (both are) voltaic cells;

Differences:
*Award **[2 max]** for any two*.
rechargeable batteries employ reversible reactions while fuel cells have irreversible reactions;
fuel cells work non-stop while rechargeable batteries take time to recharge;
fuel cells need a constant supply of reactants/fuel while rechargeable batteries do not need any other substances;
fuel cells convert energy **and** rechargeable batteries store energy;
fuel cell products must be constantly removed but not for rechargeable batteries;
fuel cells are less polluting/more expensive/weigh less/last longer (than lead-acid rechargeable batteries);
fuel cells have inert/Pt electrodes/components while lead-acid rechargeable batteries have active/non-inert/Pb and PbO_2 electrodes;
fuel cells run at higher temperatures than rechargeable batteries;
fuel cells are less portable than rechargeable batteries / fuel cells require pumps/cooling systems while rechargeable batteries do not; ***[3 max]***
*Award **[2 max]** if three valid points (one similarity and two differences) are given without comparison and **[1 max]** if two valid points are given without comparison.*

12. (a) (i) *Award **[1]** for any two.*
HDPE has higher mp;
HDPE is more rigid / less flexible;
HDPE is stronger**;** ***[1]***
Accept opposite statements for LDPE.

(ii) HDPE has straight chain **and** LDPE has branched chain / LDPE has more branched chains; ***[1]***

(b)

	HDPE	***LDPE***
Condition	Ziegler-Natta catalyst / $TiCl_3$/ $TiCl_4$ **and** $Al(OC_2H_5)_3$ catalyst;	organic peroxides;
Mechanism	ionic;	free-radical;

[4]

13. (a) fluids that have physical properties dependent on molecular orientation; ***[1]***

(b) chemical stability;
liquid-crystal phase stable over a suitable range of temperatures;
polar (in order to change orientation when an electric field is applied);
rapid switching speed; ***[2 max]***

(c) (i) liquid crystal sandwiched between polarizer and analyser / between two pieces of polaroid material; ***[1]***

(ii) plates have scratches at 90° to each other;
molecules line up with scratches/glass;
twist in molecules rotate plane of plane-polarized light so light is transmitted;
under voltage, polar molecules align with electric field so twisted structure is lost;
plane-polarized light cannot pass / pixel appears dark; ***[3 max]***

Option D — Medicines and drugs

14. (a) *Compound*:
hydrochloric acid/HCl;

Strong or weak acid:
strong (acid); ***[2]***

(b) *Type of reaction*:
neutralization;
Accept acid-base.

Ionic equation:
$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ / $2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g)$ /
$H^+(aq) + HCO_3^-(aq) \rightarrow H_2O(l) + CO_2(g)$; ***[2]***
Accept equations such as $Mg(OH)_2(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + 2\ H_2O(l)$.
Ignore state symbols.
H_3O^+ or H^+ may be used in the equation.
Do not allow inclusion of spectator ions.

(c) $Al(OH)_2NaCO_3(s) + 4HCl(aq) \rightarrow AlCl_3(aq) + NaCl(aq) + CO_2(g) + 3H_2O(l)$ /
$Al(OH)_2NaCO_3(s) + 4H^+(aq) \rightarrow Al^{3+}(aq) + Na^+(aq) + CO_2(g) + 3H_2O(l)$;
correct reactants **and** products;
correct state symbols **and** balanced; ***[2]***
M2 can only be awarded if M1 is correct.

(d) (i) excess gas in stomach/intestinal tract can cause bloating (which is prevented by addition of anti-foaming agent) / prevents flatulence / *OWTTE*; ***[1]***
Ignore any reference to heartburn.

(ii) dimethicone/hexamethyldisiloxane / simethicone/poly(dimethylsiloxane); ***[1]***
Do not accept alginates.

15. (a) intercepts pain stimulus at source / inhibits release of substances/prostaglandins that cause pain/swelling/fever; ***[1]***

(b) (i) ionic compound (which dissociates); ***[1]***.

(ii) $C_9H_7O_4^-(aq) + H^+(aq) \rightarrow C_9H_8O_4(aq)$; ***[1]***
Ignore state symbols.
Ignore arrow.

(c) (i) phenyl/benzene ring;
Do not allow just benzene or arene or the formula C_6H_6.

ester; ***[2]***
Do not allow –COO– or carbonyl/CO.

(ii) hydroxyl / phenol; ***[1]***
Allow alcohol/hydroxy but not hydroxide.
Do not allow –OH.

(iii) *Award any **[1] for any two** short-term advantages from*:
strong/powerful (pain reliever);
fast-acting / effective;
has a wide safety margin;
can quickly stop diarrhoea;
can be used in cough mixtures/medicines / antitussive properties;
works effectively with paracetamol/acetaminophen;

*Award **[1] for any two** long-term disadvantages from*:
(regular use) can lead to addiction/dependence/withdrawal symptoms;
tolerance can lead to toxic dosages;
can result in depression / apathy;
can cause mental health problems;
can result in constipation;
can result in sterility/sexually related problems;
memory loss;
serious health risk to babies who are breastfed; ***[2 max]***

*Award **[1 max]** for one correct advantage and one correct disadvantage.*

(iv) two (polar) hydroxyl groups in morphine replaced by less polar ester groups in diamorphine/heroin;
Do not allow hydroxide for hydroxyl.
Accept alcohols for hydroxyl groups.

diamorphine/heroin more soluble in non-polar lipids / diamorphine/heroin more soluble in non-polar environment of central nervous system/CNS;
Reference to solubility required.

diamorphine/heroin can penetrate blood-brain barrier more quickly / diamorphine/heroin can act more quickly in CNS (leading to increased potency); ***[3]***

16. (a)

Mind-altering drug	***Effect***
LSD	unpredictable mood swings / hypertension / impaired judgment / dilation of the pupils / (visual) hallucinations/illusions / changes body temperature;
THC	changes in auditory/visual perception / fatigue / reduces vomiting / relaxation / depresses CNS / euphoria;

[2]

(b) *Similarities*:
both contain a benzene ring/phenyl (functional group);
both contain an amine;
Do not allow benzene or arene.

*Award **[3 max]** for three statements below.*
Differences:
ether functional group in mescaline only;
indole ring in psilocybin only (ring open in mescaline) / primary amine in mescaline but secondary amine in psilocybin;
phosphate in psilocybin only;
(quaternary) cationic amine in psilocybin only; ***[4 max]***

Option E — Environmental chemistry

17. (a) (i) carbon monoxide/CO / volatile organic compounds/VOCs / particulates; ***[1]***
Allow carbon dioxide/CO_2.

(ii)

Fuel	***Method to reduce emissions***
Diesel	particulate filters/DPF/soot traps / catalytic converter/diesel-oxidation catalyst/DOC / recirculation of exhaust gases / low-sulphur diesel;
Petrol (gasoline)	catalytic converter / lean burn engine/adjusting fuel:air ratio / recirculation of exhaust gases / soot-collecting exhaust / thermal exhaust reactor ;

[2]

*Award **[1 max]** for stating "more efficient engines" for both diesel and petrol/ gasoline.*

(iii) combustion of (sulfur containing) coal;
metal extraction/smelting (of sulfide ores);
sulfuric acid/H_2SO_4 plants; ***[2]***

(b) (i) lack of wind;
bowl-shaped (topography);
thermal inversion; ***[1 max]***

(ii) $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$;
$NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$;
$NO_2(g) \rightarrow NO(g) + O\bullet(g)$;
$O\bullet(g) + O_2(g) \rightarrow O_3(g)$;
$O\bullet(g) + H_2O(g) \rightarrow 2\bullet OH(g)$;
$HO\bullet(g) + NO_2(g) \rightarrow HNO_3(aq)$;
$HO\bullet(g) + RH(g) \rightarrow R\bullet(g) + H_2O(l)$;
$R\bullet(g) + O_2(g) \rightarrow ROO\bullet(g)$;
$ROO\bullet(g) + NO_2\bullet(g) \rightarrow ROONO_2(g)$; ***[3 max]***

*Award **[2 max]** if at least one of O_3, HNO_3 or $ROONO_2$ is not shown as a product.*
Allow $NO_2(g)$ instead of $NO_2\bullet(g)$ in last equation.
Allow equations with R identified.
Ignore state symbols.
Allow radicals represented without dot if consistent throughout.

18. (a) process by which acidic (substances) leave atmosphere/return to Earth / *OWTTE*;
Do not allow acid rain. ***[1]***

(b) *Formation:*
$N_2(g) + O_2(g) \rightarrow 2NO(g) / 2NO(g) + O_2(g) \rightarrow 2NO_2(g)$;

*Acid deposition: Award **[2 max]** for any two of the following.*
$H_2O(g) + O_3(g) \rightarrow 2HO\bullet(g) + O_2(aq) / H_2O(g) + O\bullet(g) \rightarrow 2HO\bullet(g)$;
$HO\bullet(g) + NO_2(g) \rightarrow HNO_3(aq)$;
$HO\bullet(g) + NO(g) \rightarrow HNO_2(aq)$;
$2NO_2(g) + H_2O(l) \rightarrow HNO_3(aq) + HNO_2(aq)$ /
$2H_2O(l) + 4NO_2(g) + O_2(g) \rightarrow 4HNO_3(aq)$; ***[3 max]***
Allow radicals represented without dot (if consistent throughout), but penalize inconsistency once only in 17 (b)(ii) and 18 (b).

Ignore state symbols.
*Award **[2 max]** if no free radical used in describing mechanism.*

(c) shells become thinner as some of the calcium carbonate shell reacts / *OWTTE*;
Accept "dissolving of marine carbonate shells".
$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$ /
$CO_3^{2-}(s) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$ /
$CaCO_3(s) + 2H^+(aq) \rightarrow Ca^{2+}(aq) + CO_2(g) + H_2O(l)$ /
$CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(aq) + CO_2(g) + H_2O(l)$; ***[2]***
Ignore state symbols.
Allow equations with H_2SO_3 and HNO_2.
Do not accept H_2CO_3 instead of H_2O and CO_2.

19. (a) $Pb^{2+}(aq) + 2Cl^-(aq) \rightleftharpoons PbCl_2(s)$
correct reactant ions and product;
correct state symbols; ***[2]***
Do not penalize if equilibrium sign is not given.

(b) $K_{sp} = [Pb^{2+}(aq)][Cl^-(aq)]^2 = 1.7 \times 10^{-5}$;
Assumption: $[PbCl_2(s)] = 1$ / concentration of a solid is a constant (incorporated into K_{sp});
$[Cl^-] = 2[Pb^{2+}] / 1.7 \times 10^{-5} = [Pb^{2+}][Cl^-]^2 = 4x^3$;
$[Pb^{2+}(aq)] = 1.6 \times 10^{-2} / 0.016$ (mol dm^{-3}); ***[4]***
Ignore state symbols.
*Award **[3]** for correct final numerical answer if assumption is not stated or is incorrect.*

20. (a) (i) harvesting / intensive farming / monoculture/repeatedly growing same crop / heavy tillage / over-grazing / acid leaching; ***[1]***

(ii) leave land fallow / use fertilizers/manure/compost / rotate crops / graze animals / nitrogen-fixing plants; ***[1]***

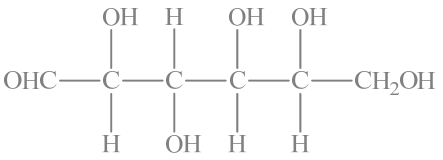
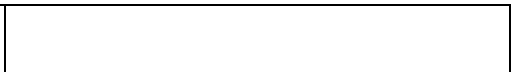
(b) irrigation waters contain dissolved salts / poor drainage;
salts left behind when water evaporates; ***[2]***

Option F — Food chemistry

21. (a) *Food*:
substance intended for (human) consumption;

Nutrient:
obtained from food **and** used by body for metabolism/to provide energy/regulate growth/repair body tissues; ***[2]***

(b)

Molecule		
Present in food	*Honey*	*Sardines*
Two named functional groups	aldehyde hydroxyl *Award **[2]** for all four correct.* *Award **[1 max]** for two or three correct.* *Allow alcohol but not hydroxide for hydroxyl.* *Allow carboxylic/alkanoic acid but not carbonyl for carboxyl.* *Names required.*	alkene carboxyl
Protein, carbohydrate or fatty acid	carbohydrate **and**	fatty acid;

[3]

(c) *Saturated fat:* no carbon-carbon double bonds/no C=C/all single carbon-carbon bonds/ all C–C **and** *Unsaturated fat:* carbon-carbon double bonds/C=C/alkene groups; ***[1]***
Mention of carbon-carbon or alkene necessary for mark.

(d) (i) *Structural formula*:
$CH_3(CH_2)_4CH_2CH_2CH_2CH{=}CH(CH_2)_7COOH$ /
$CH_3(CH_2)_4CH{=}CHCH_2CH_2CH_2CH_2(CH_2)_6COOH$;

Catalyst: nickel/Ni / palladium/Pd / platinum/Pt / copper/Cu / zinc/Zn; ***[2]***

(ii) margarine; ***[1]***

(iii) decrease (blood) levels of HDL/high-density lipoprotein cholesterol (which protects from heart disease) / increase levels of LDL/low-density lipoprotein cholesterol (increasing risk of heart disease) / less easily digested/metabolised / leads to blocked arteries; ***[1]***

(iv) carbohydrate / disaccharide; ***[1]***
Allow sucrose / sugar.

22. (a) dye is (always) water-soluble but pigment is not / *OWTTE*; ***[1]***
Some reference must be made to water for mark.

(b) (i) vitamin B_2/riboflavin is water-soluble but vitamin A/retinol is fat-soluble so large doses may result in high levels of toxicity / *OWTTE*; ***[1]***
Allow "vitamin B_2 may be eliminated more easily" or "vitamin A is stored".

(ii) β-carotene is yellow **and** chlorophyll is green;
Allow orange/red for β-carotene.
According to the colour wheel in the question, the complementary colour for violet is yellow green and for red it is bluish green. Allow these colours.

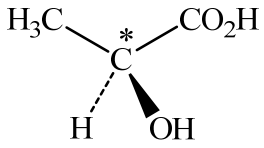
β-carotene absorption in violet region (so yellow/orange/red is complementary colour) **and** chlorophyll absorption in red region (so complementary colour is green); ***[2]***
*Allow **[1 max]** for reference to one compound alone ie, "β-carotene absorption in violet region so yellow/orange/red is complementary colour" or "chlorophyll absorption in red region so complementary colour is green".*

23. (a) initiation **and** $RH \rightarrow R\bullet + H\bullet$;
propagation **and** $R\bullet + O_2 \rightarrow ROO\bullet$ / $ROO\bullet + RH \rightarrow R\bullet + ROOH$;
termination **and** $R\bullet + R\bullet \rightarrow RR$ / $R\bullet + ROO\bullet \rightarrow ROOR$ / $ROO\bullet + ROO\bullet \rightarrow ROOR + O_2$; ***[3]***
Allow $H\bullet + H\bullet \rightarrow H_2$ *for termination.*
Award ***[1 max]*** *for stating names of steps (initiation, propagation and termination) without equations.*
Award ***[2 max]*** *for giving correct equations if names of steps are not given or are incorrect.*
Allow radicals represented without dot (if consistent throughout), but penalize inconsistency once only.

(b) chelating agents **and** reduce concentrate of free metal ions in solution;
reducing agents **and** reduce concentrations of oxygen;
free-radical scavengers/quenchers **and** form less reactive (free) radicals; ***[3]***
Award ***[1 max]*** *for stating names of agents only.*

24. (a) + rotates (plane of) plane-polarized light clockwise/right **and** – rotates (plane of) plane-polarized light counterclockwise/anticlockwise/left; ***[1]***

(b) (i) identification of chiral centre, *;



[1]

(ii) priority groups (according to atomic number/Z only) ordered counter clockwise (according to Cahn-Ingold-Prelog / CIF convention);
Do not award mark if reference is made to molecular/molar mass.
Counter clockwise may be indicated on a diagram.

S; ***[2]***

Option G — Further organic chemistry

Penalize incorrect bond linkages (eg, CH_2–HO instead of CH_2–OH) and/or missing hydrogens once only in option at first occurrence.

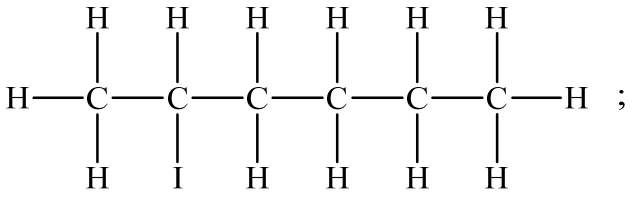
25. (a) (i) $CH_3CH_2CH=CH_2$; ***[1]***
Accept either full or condensed structural formula.

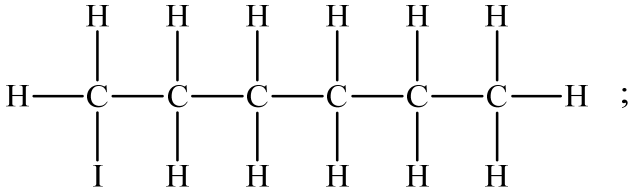
(ii) elimination / dehydration; ***[1]***
Do not accept condensation.

(iii) concentrated sulfuric is an oxidizing agent; ***[1]***
Allow "side reactions may occur with concentrated sulfuric".
Allow converse statement for phosphoric acid.
Do not allow "phosphoric acid has more protons than sulfuric".

(b) (phenol is) stronger (acid);
no positive inductive effect in phenol / positive inductive effect (of alkyl group) in butan-1-ol (strengthening OH bond, making release of H^+ difficult) / lone pair on oxygen/negative charge on phenoxide anion/$C_6H_5O^-$ can delocalize/spread round benzene ring (so charge density decreases) / negative charge localized on oxygen atom in butan-1-ol; ***[2]***

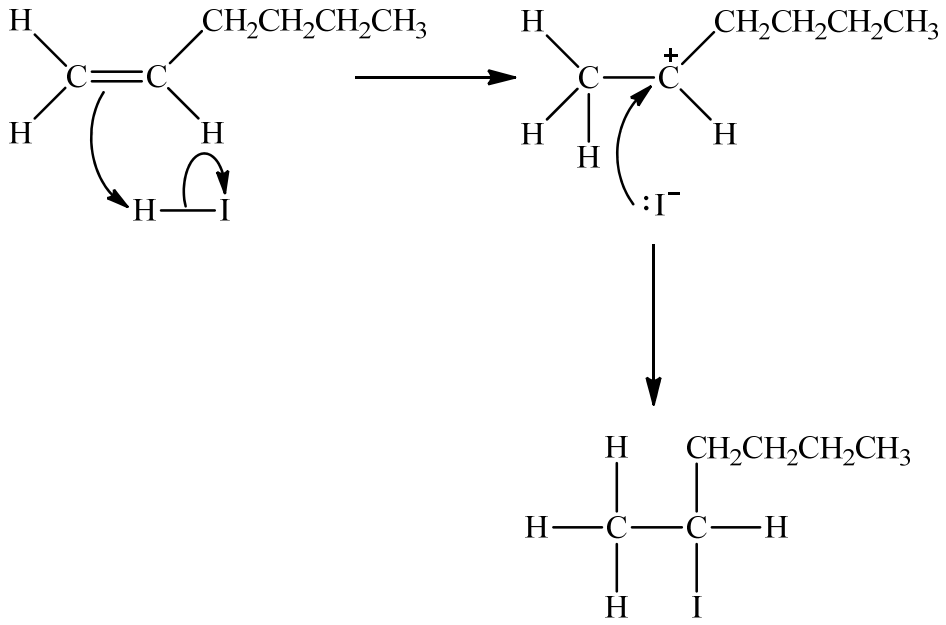
26. (a) (i)

X (Major): 

Y (Minor): 

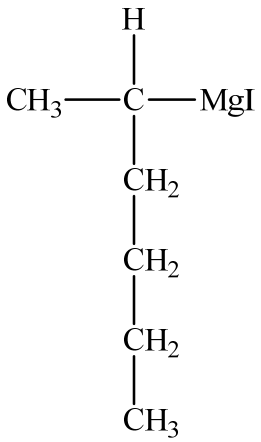
[2]

All bonds must be drawn for both structures.
*Award **[1 max]** if condensed formulas (or partially condensed) are given.*
*Award **[1 max]** if correct structures given but X and Y reversed.*

(ii) 

curly arrow going from C=C to H of HI **and** curly arrow showing I leaving;
representation of secondary carbocation;
curly arrow going from lone pair/negative charge on I^- to C^+;
Allow ecf from (a) (i). ***[3]***

(iii) positive charge is stabilized by more/two electron-releasing alkyl groups/by inductive effect of two alkyl groups / secondary carbocation more stable than primary carbocation because of greater number of electron-releasing/inductive effect of alkyl groups / *OWTTE*;
No ecf from (a) (i). ***[1]***

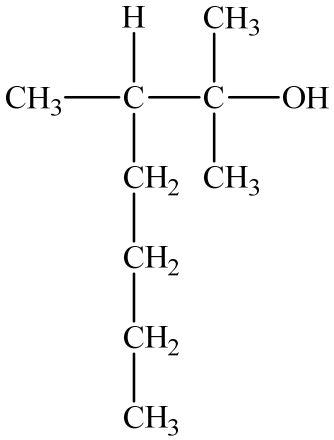
(b) (i) $CH_3CH(CH_2CH_2CH_2CH_3)MgI$ / 

[1]

Allow full or condensed structural formula.

(ii) solvent should be dry/anhydrous / non-polar/ether solvent; ***[1]***

(iii) *Structural formula*:

$CH_3CH(CH_2CH_2CH_2CH_3)C(CH_3)_2OH$ /  ;

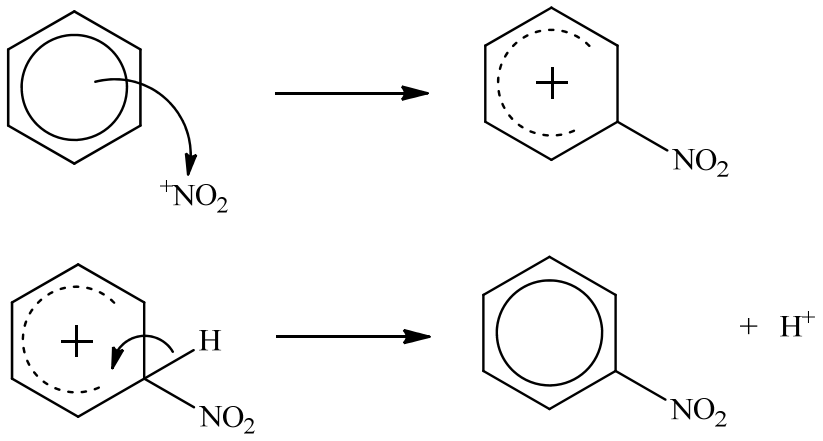
Allow full or condensed structural formula.

Class of compound:
alcohol; ***[2]***
Do not allow hydroxyl/hydroxide/hydroxy.

(iv) carbon dioxide / CO_2; ***[1]***

27. (a) (i) H_2SO_4 /sulfuric acid **and** HNO_3 /nitric acid; ***[1]***

(ii)



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

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

(b) reaction of CH_3Br with benzene;
$AlBr_3$ /$FeBr_3$ (catalyst to form methylbenzene);
Allow CH_3Cl, $AlCl_3$ and $FeCl_3$.
addition of (concentrated) HNO_3 **and** H_2SO_4 (to form 1-methyl-2-nitrobenzene); ***[3]***
Allow either correct names or formulas.
*Award **[2 max]** if order of stages reversed.*

(c) change order from (b) / *OWTTE*; ***[1]***