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MARKSCHEME

May 2010

CHEMISTRY

ExamsBuddy

Higher Level

Paper 3

20 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. Do not award more than the maximum marks allowed for part of a question.

2. Each marking point has a separate line and the end is signified 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 writing ***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. Indicate this with **ECF** (error carried forward).

10. Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **–1(U)** at the first point it occurs and **U** on the cover page.

11. Significant digits should only be considered in the final answer. Deduct **1 mark in the paper** for an **error of 2 or more digits** unless directed otherwise in the markscheme.

e.g. if the answer is 1.63:

2	*reject*
1.6	accept
1.63	accept
1.631	accept
1.6314	*reject*

Indicate the mark deduction by writing **–1(SD)** at the first point it occurs and **SD** on the cover page.

12. If a question specifically asks for the name of a substance, do not award a mark for a correct formula, similarly, if the formula is specifically asked for, do not award a mark for a correct name.

13. 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.

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

Option A — Modern analytical chemistry

A1. (a) (i) (2-)methylpropan-2-ol;
the (H atoms in the three) $–CH_3$ groups are responsible for the peak at 1.3 ppm;
the –O**H** hydrogen atom is responsible for the peak at 2.0 ppm; ***[3]***
Accept explanation with suitable diagram.

(ii) (2-)methylpropan-1-ol;
the first peak (at 0.9 ppm) is due to the (H atoms in the) two $–CH_3$ groups (bonded to the second carbon atom) / $(C\mathbf{H_3})_2CHCH_2OH$;
the peak at 3.4 ppm is due to the (H atoms in the) $–CH_2–$ group / $(CH_3)_2CHC\mathbf{H}_2OH$;
both of the peaks are split into a doublet as there is one H atom bonded on the adjacent carbon atom / *OWTTE*; ***[4]***
Accept explanations with suitable diagram.

(b) (i) butan-1-ol and butan-2-ol;

74: M^+ / $C_4H_{10}O^+$ / $CH_3CH_2CH_2CH_2OH^+$ **and** $CH_3CH_2CH(OH)CH_3^+$;

59: $C_3H_7O^+$ / $(M – CH_3)^+$ / $CH_2CH_2CH_2OH^+$ **and** $CH_2CH(OH)CH_3^+$/$CH_3CH_2CH(OH)^+$;

45: $C_2H_5O^+$ / $(M – C_2H_5)^+$ / $CH_2CH_2OH^+$ **and** $CH(OH)CH_3^+$; ***[4]***
Accept explained answers instead of formulas.

(ii) butan-1-ol;
CH_2OH^+ / $(M – C_3H_7)^+$; ***[2]***
Penalize missing + signs once only in parts (b) (i) and (ii).

(c) they all contain O–H;
they all contain C–H;
they all contain C–O; ***[2 max]***
*Award **[1max]** for the same functional groups/bonds.*

A2. (a) *The fuel*
to form a combustion mixture / to produce heat;

The atomizer
turns all the ions in the sample into atoms / *OWTTE*;

The monochromatic light source
provides light that is absorbed by the lead/metal to be detected / provides light from excited atoms of lead/metal being detected; ***[3]***

(b) concentration of Pb^{2+} from graph = 1.15 (mg dm^{-3});
Allow between 1.13 and 1.17 mg dm^{-3}.

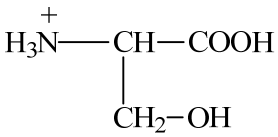
original concentration $= 1.15 \times \frac{7.5}{100} = 8.63 \times 10^{-2}$ (mg dm^{-3}); ***[2]***
Allow ECF from [Pb^{2+}].

A3. (a) retinol (absorbs visible light as it) contains conjugated double bonds/delocalized electrons;
cholesterol absorbs in the UV region as it contains one double C=C bond / does not absorb in the visible region as it has no conjugated double bonds; ***[2]***

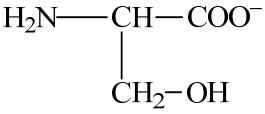
(b) the H_2O ligand is exchanged for NH_3;
Accept suitable equation with co-ordination numbers of 4 and 6.

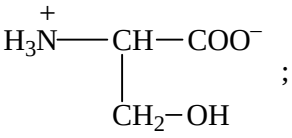
colour is due to electron transitions between the split d orbitals;
NH_3 causes a greater/different splitting than H_2O; ***[3]***

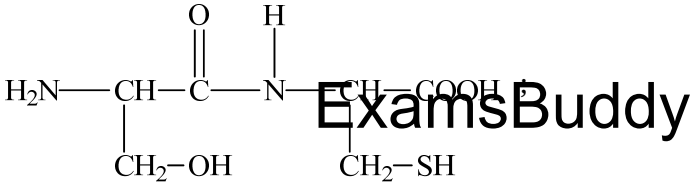
Option B — Human biochemistry

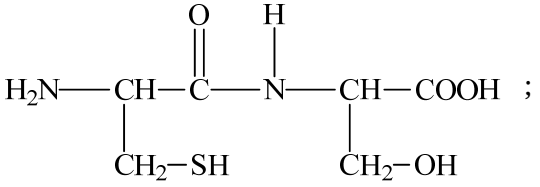
B1. (a) (i)  ; ***[1]***

If R– used or incorrect amino acid structure chosen from data booklet apply ECF for subsequent answers.

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

(b)  ; ***[1]***

(c) 

 ***[2]***

Accept –CO–NH–/–CO–HN– for peptide linkage.

(d) van der Waals attraction between non polar groups;
ionic bonding between charged groups/NH_3^+ and COO^-;
hydrogen bonding between H bonded to O or N with another O or N;
disulfide bridges/bonds between two S atoms (in cysteine);
peptide linkages/bonds between –COOH and $–NH_2$ groups; ***[5]***
*If no examples given, award **[2 max]** for 4 or 5 interactions and **[1 max]** for 2 or 3 interactions.*

B2. (a) *Beriberi*
lack/deficiency of vitamin B_1/thiamine;

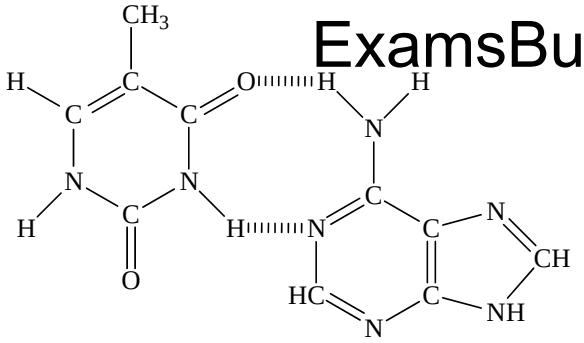
Goitre
lack/deficiency of iodine;

Pellagra
lack/deficiency of vitamin B_3/niacin; ***[3]***

(b) providing food rations containing fresh foods rich in vitamins and minerals;
providing nutrient supplements;
genetic modification of food;
adding nutrients missing to commonly consumed foods;
educating the population in healthy eating; ***[3 max]***

B3. (a) thymine is <u>covalently</u> bonded to deoxyribose/pentose sugar;
thymine bonds via a condensation reaction with the sugar / N from the thyamine bonds to C on the sugar; ***[2]***

(b) correctly choosing adenine;



thymine adenine

correctly showing the two hydrogen bonds;
labelling or identifying the bonds as hydrogen bonds; ***[3]***
*If wrong base is chosen award **[1 max]** for labelling/identifying hydrogen bonds.*

(c) each sequence of three bases represents one amino acid/triplet code;
triplet code allows for (64) permutations/codons;
DNA is transcribed to RNA;
the complete sequence for all bases is known as a genome; ***[2 max]***

(d) restriction enzymes break down the DNA into smaller fragments/minisatellites;
splits occur in the regions where there are no codons;
restriction enzymes have the ability to find a certain sequence;
the different lengths of the sequences are unique to an individual; ***[2 max]***

Option C — Chemistry in industry and technology

C1. (a) Al is more reactive than Fe / Al is higher than Fe in the reactivity series;
it is harder to reduce aluminium ores compared to iron ores / Fe^{3+} is a better oxidizing agent than Al^{3+} / *OWTTE*; ***[2]***

(b) (i) $Fe_3O_4 + 4CO \rightarrow 3Fe + 4CO_2$; ***[1]***

(ii) $Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$; ***[1]***

(c) steel has more desirable (physical) characteristics than iron / steel is stronger than iron / *OWTTE*;
by adjusting the composition of steel it can be given specific properties / *OWTTE*; ***[2]***

(d) *Positive electrode*
graphite/carbon;

Negative electrode
graphite/carbon (on a steel liner); ***[2]***

(e) much less energy required to recycle than to produce Al from ore / *OWTTE*;
less production of CO_2/greenhouse gases (graphite used in the electrolysis is converted into CO_2) / the more that is recycled the less there will be in landfill sites / *OWTTE*; ***[2]***

C2. (a) in HDPE there is little branching / in LDPE there is branching/side chains;
long chains can pack closely together/have greater forces of attraction so (HDPE) is more dense/more rigid/stronger;
side chains make (LDPE) more flexible/ideal for film products (such as food wrapping); ***[3]***
Accept opposite statements for marking points 2 and 3.

(b) LDPE: free radical mechanism;
HLPE: use of a Ziegler-Natta catalyst / ionic mechanism / coordination polymerisation; ***[2]***

(c) makes the polymer low density/good thermal insulator/expanded/softer/better shock absorber;
packaging/insulation; ***[2]***
*Award **[1 max]** if thermal insulation given for both answers.*

(d) $nH_2NC_6H_4NH_2 + nClOCC_6H_4COCl \rightarrow H\left(NH–C_6H_4–NH–CO–C_6H_4–\overset{O}{\overset{\|}{C}}\right)_n Cl + (2n–1)HCl$ /

$\left(NH–C_6H_4–NH–CO–C_6H_4–\overset{O}{\overset{\|}{C}}\right)_n + 2nHCl$

correct products;
correctly balanced; ***[2]***

(e) *liquid crystals:*
fluids with properties that depend on the molecular orientation relative to a fixed axis;

lyotropic:
solutions that show the liquid-crystal state at certain concentrations; ***[2]***

C3. (+) electrode made of titanium and (–) electrode made of steel;
(+) $2Cl^- \rightarrow Cl_2 + 2e^-$;
(–) $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ / $2H^+ + 2e^- \rightarrow H_2$;
environmental as poisonous mercury leaks from mercury cell / *OWTTE* / membrane cell is much cheaper to run; ***[4]***

Option D — Medicines and drugs

D1. (a) prostaglandins are involved in the transmission of pain impulses (to the brain) / *OWTTE*; ***[1]***

(b) morphine (temporarily) bonds to/inhibits receptor sites in the brain (without depressing central nervous system) / *OWTTE*; ***[1]***

(c) causes blood disorders;
causes damage to kidney;
causes damage to liver;
causes damage to brain; ***[2 max]***

(d) preventing (recurrence of) heart attacks/strokes / reduces blood clotting / thins the blood / anti-inflammatory; ***[1]***

(e) (i) phenol / alcohol / hydroxyl; ***[1]***

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

(f) ethanoic acid / ethanoic anhydride / ethanoyl chloride;
Accept formula instead of name.

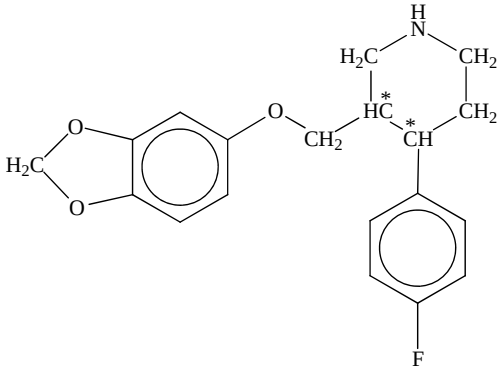
diesterification / esterification / condensation; ***[2]***

D2. (a) penicillins interfere with the enzymes that bacteria need to make cell walls / interfere with formation of bacterial cell walls / *OWTTE*;
the increased osmotic pressure causes the bacterium to die / the bacterial cells absorb too much water and burst / *OWTTE*; ***[2]***

(b) resistant to penicillinase enzyme / more resistant to bacteria breaking it down / effective against bacteria that are resistant (to penicillin G);
resistance to breakdown by stomach acid (so can be taken orally) / *OWTTE*; ***[2]***

(c) amide group / –CONH– / peptide;
ring is strained / *OWTTE*;
ring breaks easily so (the two fragments similar to cysteine and valine) then bond(s) covalently to the enzyme that synthesizes the bacterium cell wall (so blocking its action); ***[3]***

D3. (a)



[2]

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

(b) different enantiomers can cause different (physiological) effects in the body;
thalidomide – one isomer prevented morning sickness, the other caused fetal abnormalities / ibuprofen – one isomer is more effective than the other / DOPA – one isomer helps manage Parkinson¨disease, the other has no physiological effects; ***[2]***
Accept other correct examples.

(c) chiral auxiliaries are themselves chiral;
attach to the non-chiral molecule (to enable the desired enantiomer to be formed);
after the desired enantiomer is formed the chiral auxiliary is removed/recycled; ***[2 max]***

(d) (i) it turns the (relatively non-polar) isopentane into anionic/polar species;
it increases its solubility in aqueous solutions / facilitates distribution around the body; ***[2]***

(ii) (secondary) amine group / non-bonding pair of electrons on (electronegative) N atom; ***[1]***

Option E — Environmental chemistry

E1. (a) *Carbon monoxide*
incomplete combustion of fossil fuels;

Oxides of nitrogen
combination of nitrogen and oxygen at high temperatures (inside an internal combustion engine); ***[2]***

(b) hot gases passed over a catalyst of Pt/Rh/Pd / gases adsorbed onto surface of metal;
$2CO + 2NO \rightarrow 2CO_2 + N_2$; ***[3]***
*Award **[1]** for correct reactants and products and **[1]** for correctly balancing.*

(c) volatile organic compounds/VOCs; ***[1]***

(d) electrostatic precipitation;
charged particles attracted to electrodes which are periodically shaken / *OWTTE*;

OR

wet scrubbers;
water spray washes particulates from the exhaust gases;

OR

cyclone extractors;
particulates removed by spinning/vortex motion; ***[2]***

E2. (a) *Advantage*
reduce volume / stable odour-free residue / source of energy;

Disadvantage
expensive to build and operate / can form dioxins/toxic gases / requires energy / adds to greenhouse effect; ***[2]***

(b) low activity **and** short half-life;
materials (*e.g.* gloves, paper towels, clothes) that have been in proximity to radioactivity / any named source (such as smoke detectors); ***[2]***

(c) *methods:*
vitrification / encasing in concrete / burying in <u>deep</u> places;

problems: [2 max]
may leak into water table;
remains active for a very long time;
geological instability (*e.g.* earthquakes);
potential weapon for terrorists; ***[3 max]***

E3. (a) use of oxygen/air **and** bacteria/microorganisms;
trickle filters / activated sludge; ***[2]***

(b) all nitrates are (very) soluble in water so cannot be removed by precipitation; ***[1]***

(c) $Al^{3+} + PO_4^{3-} \rightarrow AlPO_4$; ***[1]***

(d) $K_{sp} = [Ni^{2+}] \times [OH^-]^2$;
$[OH^-] = 2[Ni^{2+}]$ hence $K_{sp} = 4[Ni^{2+}]^3$;
$[Ni^{2+}] = (\frac{6.50 \times 10^{-18}}{4})^{\frac{1}{3}} = 1.18 \times 10^{-6}$ mol dm^{-3};
Mass of Ni^{2+} in 1 $dm^3 = 58.71 \times 1.18 \times 10^{-6} = 6.90 \times 10^{-5}$ g;
*Award **[4]** for correct final answer.*

Accept
$K_{sp} = [Ni^{2+}] \times [OH^-]^2$;
pH = pOH = 7 $\rightarrow$ *$[OH^-] = 10^{-7}$ mol dm^{-3}*;
$[Ni^{2+}] = \frac{6.50 \times 10^{-18}}{(10^{-7})^2} = 6.50 \times 10^{-4}$ *mol dm^{-3}*;
Mass of Ni^{2+} in 1 $dm^3 = 6.50 \times 10^{-4} \times 58.71 = 3.82 \times 10^{-2}$ g; ***[4]***
*Award **[4]** for correct final answer.*

(e) add excess hydroxide ions / increase the pH;
more $Ni(OH)_2$ will precipitate due to common ion effect / *OWTTE*; ***[2]***

Option F — Food chemistry

F1. (a) a food is a substance intended for (human) consumption;
a nutrient is obtained from food **and** used by the body to provide energy/regulate growth/maintain and repair body tissues; ***[2]***

(b) they have the empirical formula CH_2O;
they contain <u>one</u> carbonyl/C=O group;
they contain at least two hydroxy/–OH groups; ***[3]***

(c) condensation reaction;
(NH_2 of) amino acid/protein/peptide;
(CHO of) reducing sugar/glucose/lactose;
presence of lysine gives the most brown colour;
presence of cysteine gives the least brown colour; ***[3 max]***

F2. (a) pigments absorb visible light;
and scatter/reflect/transmit the remaining light; ***[2]***

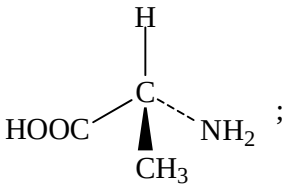
(b) (i) no effect as it lies outside the visible region/is in the UV / *OWTTE*; ***[1]***

(ii) the colour will be the complementary colour to the colour absorbing at 530 nm / it will be red as 530 nm is blue-green / *OWTTE*; ***[1]***

(c) oxidation;
temperature;
pH/acidity/basicity;
presence of metal ions; ***[2 max]***

F3. (a) correct identification of one of the chiral carbon atoms / contains chiral/asymmetric carbon atom(s);
+(*d*) and –(*l*) refer to the direction in which the enantiomers rotate the plane of plane-polarized light / *OWTTE*; ***[2]***

(b) (i)



;

[1]

(*Ensure only two of the groups have been switched to give the correct structure of the enantiomer of A).*

(ii) the substituents **CO**OH, **R**, **N**H_2 and H are arranged with the H atom pointing away from the viewer;
if they are arranged clockwise it is the D form;
so **B** is the D isomer; ***[3]***
Accept other correct statements of the CORN rules. Must give reason for third marking point.

F4. (a) (i) the (two) tertiary butyl groups/$-C(CH_3)_3$ groups;
phenol group; ***[2]***

(ii) free radical inhibitor/scavenger / reacts with and removes free radicals / *OWTTE*; ***[1]***

(b) it is a reductant/reducing agent / electron donor;
removes/reduces concentration of oxygen; ***[2]***

Option G — Further organic chemistry

G1. (a) $C_2H_5MgBr + H_2O \rightarrow C_2H_6 + Mg(OH)Br$ ***[2]***

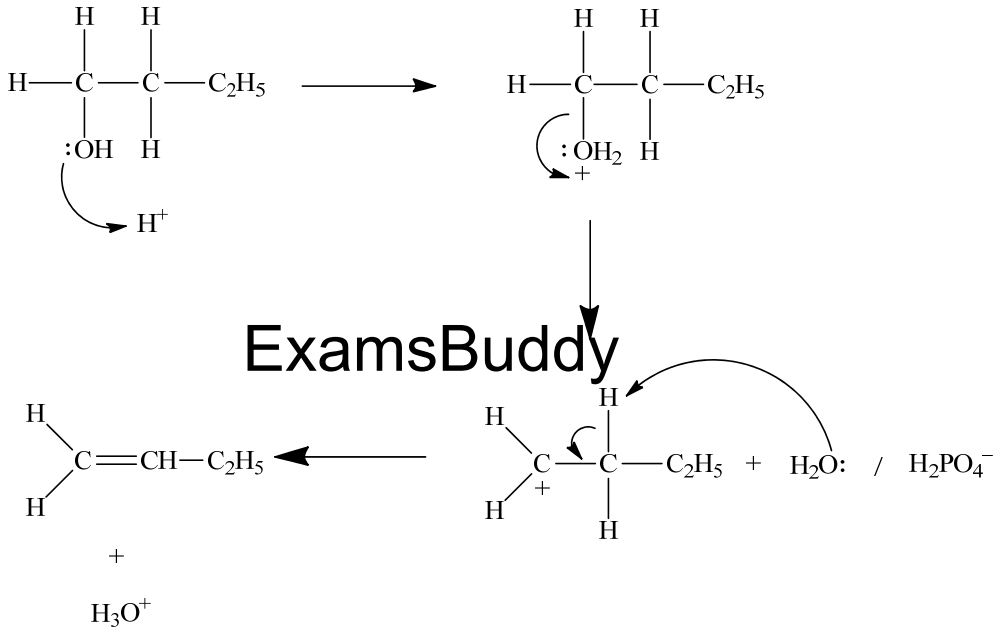
*Award **[1]** for C_2H_6 and **[1]** for correct equation.*

(b) (i) butan-2-ol/2-butanol;
$CH_3CH_2CH(OH)CH_3$; ***[2]***

(ii) 2-methylbutan-2-ol;
$C_2H_5C(CH_3)_2OH$; ***[2]***

(c) (i) but-1-ene/1-butene; ***[1]***

(ii)



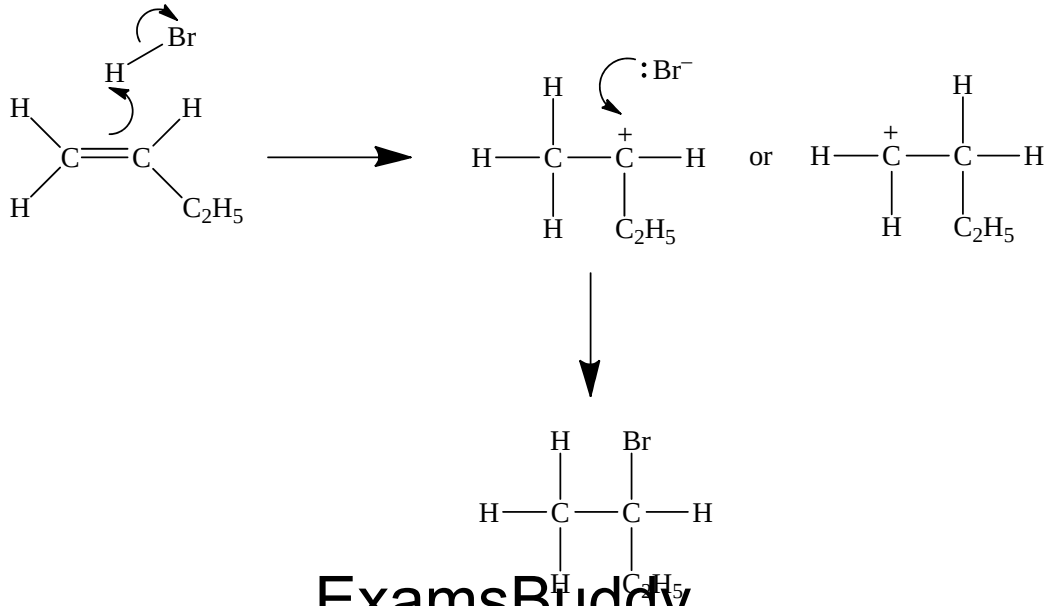
curly arrow going from lone pair on O to H^+;
representation of positively charged O intermediate **and** curly arrow showing H_2O leaving;
curly arrow going from lone pair on O of $H_2O/H_2PO_4^-$ to H **and** curly arrow going from CH bond to $C–C^+$ to form C=C; ***[3]***
No mark awarded if C^+ is not represented.

G2. (a) as the bromine approaches the alkene an induced dipole is formed / *OWTTE*; ***[1]***

(b) (i) 2,3-dibromobutane; ***[1]***

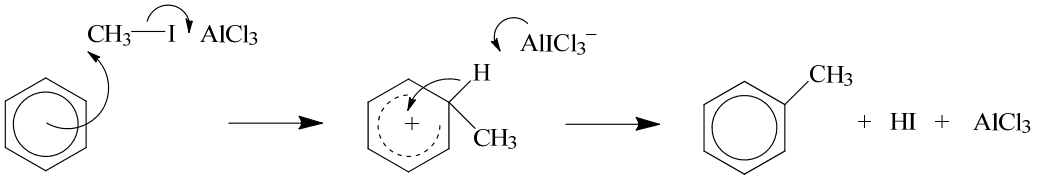
(ii) 2-bromobutane; ***[1]***

(c)



showing curly arrow from double bond to H (in H–Br) **and** curly arrow from bond in H–Br to Br;
showing the curly arrow from the lone pair/negative charge on Br^- to the secondary carbocation **and** 2-bromobutane as correct product;
stating that the secondary carbocation will be formed in preference to the primary carbocation;
the two positive/electron releasing inductive effects due to the two R– groups on the secondary carbocation make it more stable; ***[4]***

G3. (a) aluminium chloride / iodide / iron chloride;
Accept $AlCl_3$ / AlI_3 / $FeCl_3$.



showing curly arrows from benzene ring to CH_3– **and** curly arrow from bond in CH_3–I to catalyst;
Accept prior formation of electrophile to give CH_3^+ and $AlICl_3^-$/AlI_4^-.

correctly showing intermediate;
Accept mechanism with corresponding Kekulé structures.

curly arrow from –H into ring and curly arrow from catalyst anion to H; ***[4]***

(b) (i) 1-methyl-2-nitrobenzene **and** 1-methyl-4-nitrobenzene; ***[1]***
*Accept 2-methylnitrobenzene **and** 4-methylnitrobenzene.*
*Accept 2-nitromethylbenzene **and** 4-nitromethylbenzene.*
*Accept o-methylnitrobenzene **and** p-methylnitrobenzene.*

(ii) NO_2^+ / nitronium ion;
the (concentrated) sulfuric acid protonates the nitric acid / $HNO_3 + H_2SO_4 \rightarrow H_2NO_3^+ + HSO_4^-$;
the $H_2NO_3^+$ formed loses water / $H_2NO_2^+ \rightarrow H_2O + NO_2^+$; ***[3]***
Accept $HNO_3 + H_2SO_4 \rightarrow NO_2^+ + H_2O + H_2SO_4^-$ for the second and third points.