M13/4/CHEMI/SP2/ENG/TZ2/XX/M

International Baccalaureate®
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MARKSCHEME

May 2013

CHEMISTRY

Standard Level

Paper 2

14 pages

Subject Details: Chemistry SL Paper 2 Markscheme

Mark Allocation

Candidates are required to answer **ALL** questions in Section A **[30 marks]** and **ONE** question in Section B **[20 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.

SECTION A

1. (a) systematic (error); ***[1]***
Do not accept parallax.

(b) closeness of agreement of a set of measurements to each other / *OWTTE*; ***[1]***
Allow reproducibility/consistency of measurement / measurements with small random errors/total amount of random errors/standard deviation / a more precise value contains more significant figures / OWTTE.

(c) potassium permanganate has a very dark/deep (purple) colour so cannot read bottom of meniscus / *OWTTE*; ***[1]***

(d) (i) gain (of electrons); ***[1]***

(ii) VII / +7; ***[1]***
Do not accept *7 or 7+*.

(e) (i) volume $= 16.80\,(\text{cm}^3)$ / $18.00 - 1.20\,(\text{cm}^3)$;
amount $\left(= \dfrac{16.80 \times 5.00 \times 10^{-3}}{1000}\right) = 8.40 \times 10^{-5}\,(\text{mol})$; ***[2]***
*Award **[2]** for correct final answer.*

(ii) $(8.40 \times 10^{-5} \times 5 \times 10) = 4.20 \times 10^{-3}\,(\text{mol per } 250\,\text{cm}^3)$; ***[1]***

(iii) $(55.85 \times 4.20 \times 10^{-3}) = 0.235\,(\text{g})$; ***[1]***
Do not penalize if 56 g mol^{-1} is used for atomic mass of iron.

(iv) $\left(\dfrac{0.235 \times 100}{1.65} =\right) 14.2\,\%$; ***[1]***
No ECF if answer >100 %.

(f) (i) MnO_2; ***[1]***

(ii) due to insufficient acid (in flask) / *OWTTE*; ***[1]***

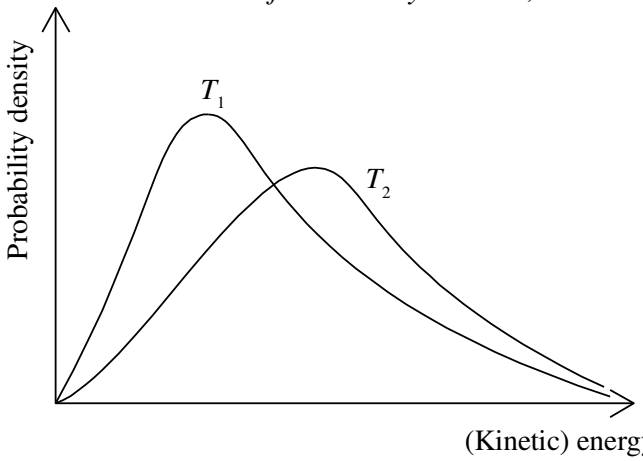
2. (a) $4H_2O(l) + 3CO_2(g) \rightarrow C_3H_8(g) + 5O_2(g) \quad \Delta H = +2219\,(kJ\,mol^{-1})$;
$4H_2(g) + 2O_2(g) \rightarrow 4H_2O(l)$: $\Delta H = ((-286)(4) =) -1144\,(kJ\,mol^{-1})$;
$3C(s) + 3O_2(g) \rightarrow 3CO_2(g)$: $\Delta H = ((-394)(3) =) -1182\,(kJ\,mol^{-1})$;
$\Delta H = ((-286)(4) + (-394)(3) + (+2219) =) -107\,(kJ\,mol^{-1})$; ***[4]***
*Award **[4]** for correct final answer.*

(b) minimum energy needed (by reactants/colliding particles) to react/start/initiate a reaction / for a successful collision; ***[1]***
Allow energy difference between reactants and transition state.

(c) *x-axis label:* (kinetic) energy/(K)E **and** *y-axis label:* fraction of molecules/ particles / probability density;
Allow velocity/speed for x-axis.
Allow frequency / number of molecules/particles or (kinetic) energy distribution for y-axis.

correct shape of a Maxwell–Boltzmann energy distribution curve;

Do not award mark if curve is symmetric, does not start at zero or if it crosses x-axis.



two curves represented with second curve for $T_2 > T_1$ to right of first curve, lower peak than first curve and after the curves cross T_2 curve needs to be above T_1 curve; ***[3]***

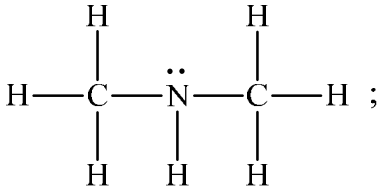
3. (a) (i) $[H^+]$ increased by factor of 10; ***[1]***
Allow an increase of 1.426×10^{-3} mol dm^{-3}.

(ii) ethanoic acid; ***[1]***
Allow acetic acid.

(b) $CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)$
correct chemical equation;
correct state symbols; ***[2]***
Allow $CaSO_4(aq)$ instead of $CaSO_4(s)$.
M2 can only be scored if M1 is correct.
*Award **[1max]** if $H_2CO_3(aq)$ is given instead of $H_2O(l) + CO_2(g)$.*

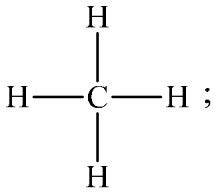
4. (a) van der Waals'/London/dispersion **and** dipole-dipole; ***[1]***
Allow abbreviations for van der Waals' as vdW or for London/dispersion as FDL.

(b) (i) $(CH_3)_2NH$:



;
Lone pair not necessary.

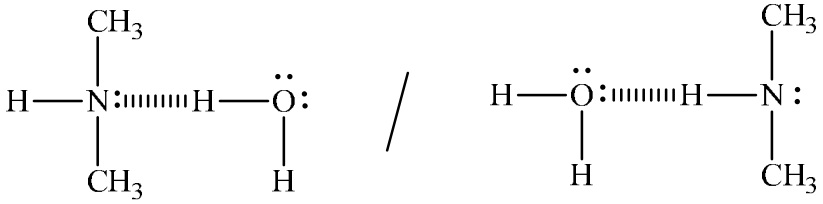
CH_4 :



; ***[2]***
All bonds (including CH bonds of methyl groups) must be shown for both structures.
Penalize missing hydrogens once only.

(ii) $(CH_3)_2NH$;
(intermolecular) attraction between hydrogen (atom) in O–H/N–H (polar) bond and (lone pair on) electronegative N/O / hydrogen between two very electronegative elements (nitrogen and oxygen) / *OWTTE*; ***[2]***
Accept hydrogen bonded to nitrogen which is electronegative/has lone pair.
Do not allow ECF if M1 incorrect.

(iii) representative drawing showing hydrogen bond between $(CH_3)_2NH$ and H_2O ; ***[1]***



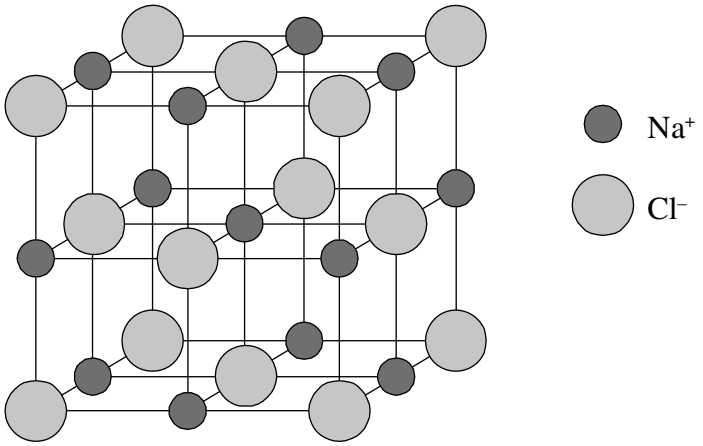
Do not penalize if lone pair as part of hydrogen bond is not shown.
Allow any representation of hydrogen bond (for example, dashed lines, dots etc.) which differs from full stick representation of the other covalent bonds in amine and water molecules.
Allow full line if labelled as hydrogen bond.
Lone pairs on oxygen not necessary.
Award mark if two hydrogen bonds drawn between the molecules from the lone pair and the H on the N.

SECTION B

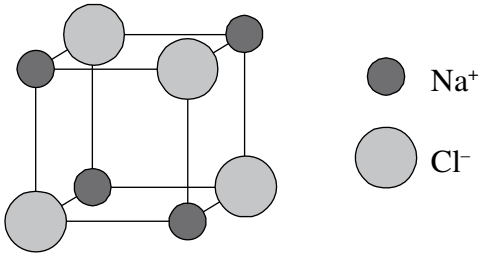
5. (a) (i) (electrostatic) attraction between oppositely charged ions/cation and anion/ positive and negative ions; ***[1]***
Do not allow electrostatic attraction between metals and non-metals.

(ii) *Description:*
a lattice is a giant, regular/repeating arrangement/array;
of (chloride) anions/negative ions/Cl^- **and** (sodium) cations/positive ions/Na^+;
each sodium ion surrounded by six chloride ions / each chloride ion surrounded by six sodium ions;
M2 may also be scored from a diagrammatical key or labels on each ion.
M3 may also be scored by a correctly represented cubic representation showing the six-coordination around either the sodium ion or each chloride ion.

Diagram:
cubic lattice type representation (showing **a minimum of one sub-cube and** alternating Na^+ and Cl^- ions);
Cl^- shown represented bigger than Na^+ on diagram; ***[4 max]***

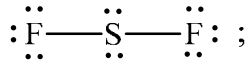
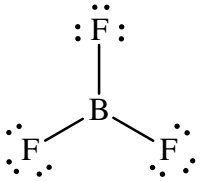
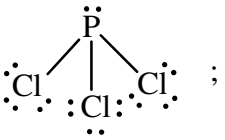


*Award **[4]** for correctly drawn diagram (like above) with ions clearly identified.*
*Award **[3 max]** for the following diagram below if no explanation in words is given.*



(iii) $(NH_4)_3PO_4$; ***[1]***
Allow use of square brackets.

(b) (i)

	SF_2	BF_3	PCl_3
Lewis (electron dot) structure	 ;	 ;	 ;
	Allow any combination of dots/crosses or lines to represent electron pairs. *Penalize missing lone pairs once only.*		
Shape	*v*-shaped/bent/ angular; *Do not allow mark for stating tetrahedral (as this is the electron-domain geometry and not the molecular geometry).* *Penalize tetrahedral once only.*	trigonal/triangular planar; *Do not allow just planar.*	trigonal/triangular pyramidal; *Allow pyramidal (since SL).* *Do not allow mark for stating tetrahedral (as this is the electron-domain geometry and not the molecular geometry).* *Penalize tetrahedral once only.*
	Do not allow ECF from Lewis structures with an incorrect number of negative charge centres.		

[6]

(ii) allow any bond angle in the range 97° to less than 109.5° (experimental value is 98°);
due to four negative charge centres/four electron pairs/four electron domains (two of which are lone pairs)/tetrahedral arrangement of electron pairs;
extra repulsion due to two lone pairs of electrons repelling each other / lone pairs occupy more space (than bonding pairs) so F–S–F bond angle decreases from 109.5° / *OWTTE;* ***[3]***
Answers which refer to electronegativity consideration of F's <u>also</u> are correct, as long as LP/LP repulsion is <u>also</u> mentioned to score M3.

(iii) SF_2:

polar because net dipole moment present in molecule / SF bond polarities do not cancel each other out / unsymmetrical distribution of charge / *OWTTE*;

BF_3:

non-polar because no net dipole moment present in molecule / BF bond polarities do cancel each other out / symmetrical distribution of charge / *OWTTE*;

PCl_3:

polar because net dipole moment present in molecule / PCl bond polarities do not cancel each other out / unsymmetrical distribution of charge / *OWTTE*; ***[3]***

*Award **[1 max]** for SF_2 polar, BF_3 non-polar, PCl_3 polar even if explanations are incorrect or are not given.*
Polarity may also be explained using diagrams showing net dipole moments.

(c) *IBr*:
$\Delta\chi = (3.0 - 2.7) = 0.3$, covalent

$BaCl_2$:
$\Delta\chi = (3.2 - 0.9) = 2.3$, ionic

CsI:
$\Delta\chi = (2.7 - 0.8) = 1.9$, ionic

HBr:
$\Delta\chi = (3.0 - 2.2) = 0.8$, covalent ***[2]***

*Award **[2]** for all four correct, **[1]** for two or three correct.*
*Award **[1 max]** for stating IBr, HBr covalent **and** $BaCl_2$, CsI ionic.*
Allow polar covalent instead of covalent.
Allow large electronegativity difference for ionic and small electronegativity difference for covalent.

6. (a) (i) atoms of same element / atoms with same number of protons/atomic number/Z;
Do not allow elements instead of atoms in second alternative.

(but) different numbers of neutrons/mass number/*A*; ***[2]***

(ii)

Isotope	Number of protons	Number of neutrons	Number of electrons
^{35}Cl	17	18	17
^{37}Cl	17	20	17

; ; ***[2]***

*Allow **[1 max]** for 17 p, 17 e for both if n's are omitted or incorrect.*
*Allow **[1 max]** for ^{35}Cl: 18 n **and** ^{37}Cl: 20 n if p's and e's are omitted.*

(iii) (for ^{35}Cl: x%) $35x + 3700 - 37x = 3545$;
Allow other alternative mathematical arrangements.

$^{35}Cl = 77.5\%$ **and** $^{37}Cl = 22.5\%$; ***[2]***
*Award **[1 max]** for correct percentages if no correct working is shown.*

(iv) 2,8,8; ***[1]***
Allow $1s^2 2s^2 2p^6 3s^2 3p^6$ or [Ne]$3s^2 3p^6$ or [Ar].

(b) (i) ability of atom/nucleus to attract bonding/shared pair of electrons / attraction of nucleus for bonding/shared pair of electrons / *OWTTE*; ***[1]***
Do not allow element instead of atom/nucleus.

(ii) increasing atomic radii (down the group) / *OWTTE*;
so reduced attraction (for the bonding electrons) / *OWTTE*;
screening/shielding effect of inner electrons / *OWTTE*; ***[2 max]***
Allow more energy levels/electron shells for M1.
Do not accept decrease in nuclear charge.

(iii) $2KBr(aq) + Cl_2(aq) \rightarrow 2KCl(aq) + Br_2(aq)$; ***[1]***
Ignore state symbols.
Allow ionic equation.

(iv) colourless/pale yellow/green to yellow/orange/brown; ***[1]***
Start and end colours must both be mentioned.

(c) (i) (sewage) pipes / (food) packaging / clothing / insulation (for electric wires/cables) / ceiling tiles / guttering; ***[1]***
Allow other suitable alternatives (there are many possible examples here – these are some of the major ones).
Apply list principle.

(ii) *Bonds breaking*:
$1\times(C{=}C)+4\times(C{-}H)+1\times(Cl{-}Cl)$
$=(1)(612)+(4)(413)+(1)(243)\ /=(+)2507\,(\text{kJ mol}^{-1})$;

Bonds forming:
$1\times(C{-}C)+4\times(C{-}H)+2\times(C{-}Cl)$
$=(1)(347)+(4)(413)+(2)(346)\ /=-2691\,(\text{kJ mol}^{-1})$;

Enthalpy change:
$(2507-2691=)-184\,(\text{kJ mol}^{-1})$;

OR

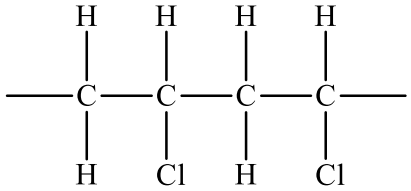
Bonds breaking:
$1\times(C{=}C)+1\times(Cl{-}Cl)$
$=(1)(612)+(1)(243)\ /=(+)855\,(\text{kJ mol}^{-1})$;

Bonds forming:
$1\times(C{-}C)+2\times(C{-}Cl)$
$=(1)(347)+(2)(346)\ /=-1039\,(\text{kJ mol}^{-1})$;

Enthalpy change:
$(855-1039=)-184\,(\text{kJ mol}^{-1})$; ***[3]***
*Award **[3]** for correct final answer.*

(iii) exothermic; ***[1]***
Do not award mark unless based on some value for part (ii).

(iv) representation of PVC showing two repeating units; ***[1]***
For example,



Brackets not necessary but continuation bonds must be given.
No penalty if chlorines are not on same side.
No penalty if chlorines are on two middle C atoms or on two end C atoms.

(v) monomers are smaller molecules / monomers have smaller mass / smaller surface area than polymers;
weaker/fewer intermolecular/London/dispersion/van der Waals' forces (of attraction); ***[2]***
Allow reverse argument.
Allow abbreviation for London/dispersion as FDL or for van der Waals' as vdW.
Award zero if reference is made to breaking of bonds.

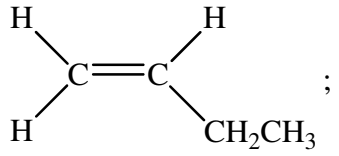
7. (a) (i) alkene;
alcohol;
Allow hydroxyl (group) but not hydroxide.

ketone; ***[2 max]***
Accept carbonyl.

(ii) correctly drawn circle around each of the two functional groups and labelled 1 and 2; ***[1]***
Mark can be scored for (ii) without labels (1 and 2) only if no answer is given in (i).
Apply ECF from (incorrect) functional groups in (i).

(b) compounds with same molecular formula but different arrangements of atoms; ***[1]***
Allow compounds with same molecular formula but different structural formulas.

(c) (i) but-2-ene; ***[1]***
Allow 2-butene.

(ii) 

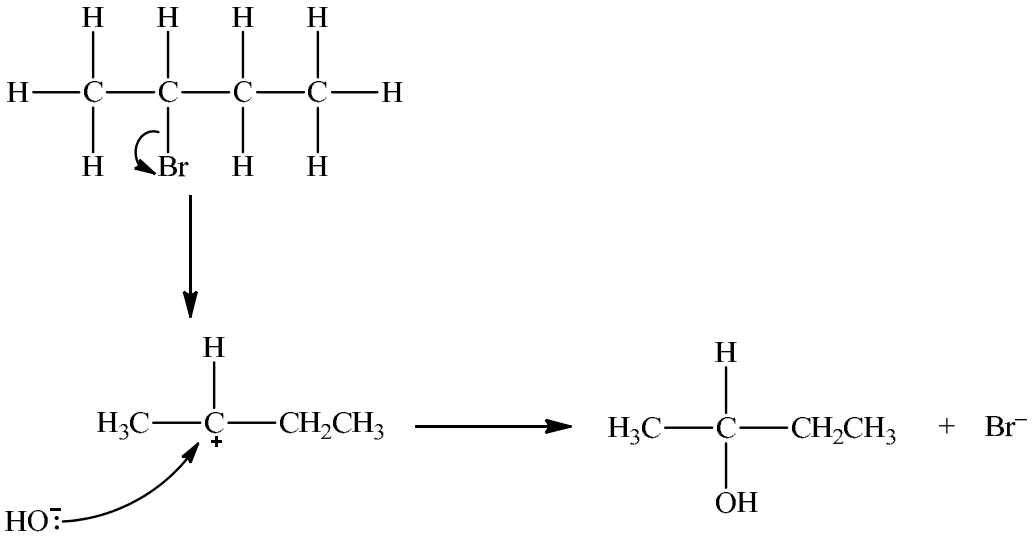
; ***[1]***

(iii) **Q:** $CH_3CH(OH)CH_2CH_3$;
R: $CH_3CH_2CH_2CH_3$; ***[2]***
Condensed or full structural formulas may be given.

(iv) platinum / palladium / nickel; ***[1]***
Allow Pt / Pd / Ni.

(v) *Since secondary bromoalkane could be either S_N1 and S_N2 so allow S_N1 or S_N2 for M1 –M4.*

S_N1:



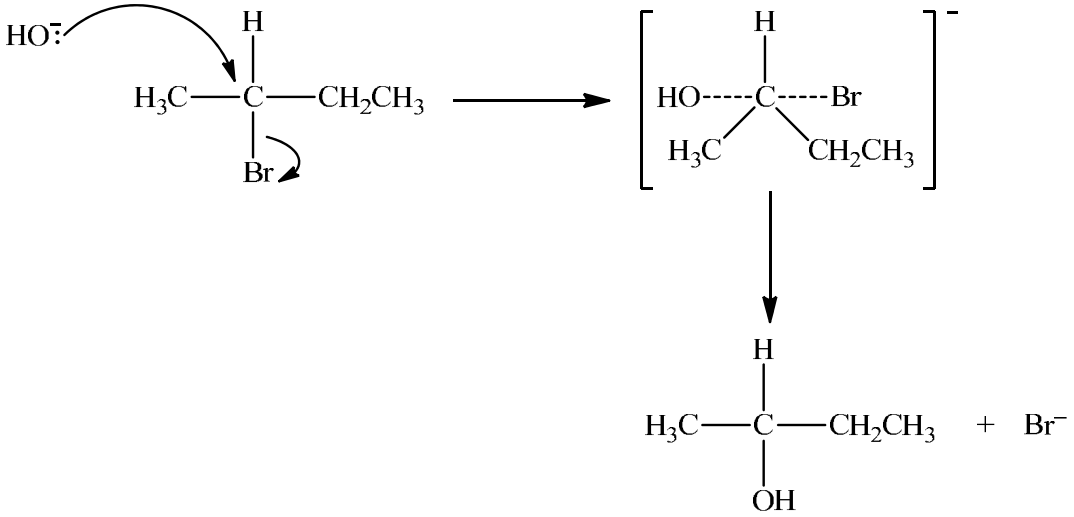
curly arrow showing Br leaving;
Do not allow arrow originating from C to C–Br bond.

representation of secondary carbocation;
curly arrow going from lone pair/negative charge on O in HO^- to C^+;
Do not allow arrow originating on H in OH^-.

formation of $CH_3CH(OH)CH_2CH_3$ **and** Br^- ;
Allow formation of NaBr instead of Br^-.

OR

S_N2:



curly arrow going from lone pair/negative charge on O in HO^- to C;
Do not allow curly arrow originating on H in OH^-.

curly arrow showing Br leaving;
Accept curly arrow either going from bond between C and Br to Br in 2-bromobutane or in the transition state.
Do not allow arrow originating from C to C – Br bond.

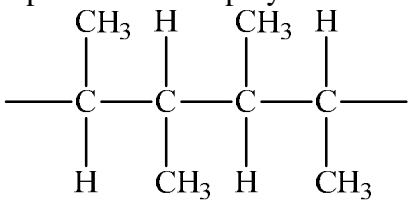
representation of transition state showing negative charge, square brackets and partial bonds;
Do not penalize if HO and Br are not at 180° to each other.
Do not award M3 if OH—C bond is represented.

formation of $CH_3CH(OH)CH_2CH_3$ **and** Br^-; ***[4]***
Allow formation of NaBr instead of Br^-.

(vi) $H_3CCOCH_2CH_3$; ***[1]***
Condensed or full structural formula may be given.
Apply ECF from (c)(iii).

(vii) butan-2-one; ***[1]***
Allow 2-butanone or butanone.

(viii) representation of polymer showing two repeating units; ***[1]***



Brackets not necessary but continuation bonds must be given.
No penalty if methyl groups given on same side.

(d) (i) $n_C : \left(\frac{76.84}{12.01}\right) = 6.398\,\text{mol}$ **and** $n_H : \left(\frac{12.92}{1.01}\right) = 12.79\,\text{mol}$ **and**
$n_O : \left(\frac{10.24}{16.00}\right) = 0.6400\,\text{mol}$;
Allow integer values for atomic masses.

dividing across by lowest number to give integer values;
$C_{10}H_{20}O$; ***[3]***
*Award **[3]** for correct final answer.*

(ii) ($M(C_{10}H_{20}O) = 156.30\,(\text{g mol}^{-1})$, therefore empirical formula = molecular formula =) $C_{10}H_{20}O$; ***[1]***