edexcel

Mark Scheme (Results)
Summer 2014

IAL Chemistry (WCH04/01)
General Principles of Chemistry I

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications come from Pearson, the world's leading learning company. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information, please visit our website at www.edexcel.com.

Our website subject pages hold useful resources, support material and live feeds from our subject advisors giving you access to a portal of information. If you have any subject specific questions about this specification that require the help of a subject specialist, you may find our Ask The Expert email service helpful.

www.edexcel.com/contactus

Pearson: helping people progress, everywhere

Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2014
Publications Code IA038356*

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	**D**		**1**

Question Number	Correct Answer	Reject	Mark
2	**A**		**1**

Question Number	Correct Answer	Reject	Mark
3	**D**		**1**

Question Number	Correct Answer	Reject	Mark
4	**D**		**1**

Question Number	Correct Answer	Reject	Mark
5	**C**		**1**

Question Number	Correct Answer	Reject	Mark
6(a)	**A**		**1**

Question Number	Correct Answer	Reject	Mark
6 (b)	**B**		**1**

Question Number	Correct Answer	Reject	Mark
7(a)	**D**		**1**

Question Number	Correct Answer	Reject	Mark
7(b)	**C**		**1**

Question Number	Correct Answer	Reject	Mark
8	**A**		**1**

Question Number	Correct Answer	Reject	Mark
9	**C**		**1**

Question Number	Correct Answer	Reject	Mark
10	**B**		**1**

Question Number	Correct Answer	Reject	Mark
11	**B**		**1**

Question Number	Correct Answer	Reject	Mark
12	**B**		**1**

Question Number	Correct Answer	Reject	Mark
13	**A**		**1**

Question Number	Correct Answer	Reject	Mark
14	**B**		**1**

Question Number	Correct Answer	Reject	Mark
15 (a)	**C**		**1**

Question Number	Correct Answer	Reject	Mark
15(b)	**A**		**1**

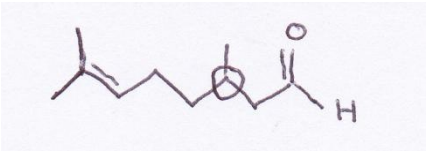
Question Number	Correct Answer	Reject	Mark
16	**C**		**1**

Question Number	Correct Answer	Reject	Mark
17	**B**		**1**

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
18(a)	$C_{10}H_{18}O$ **ALLOW** any order i.e. C_{10} OH_{18} /H_{18} $C_{10}O$ /$H_{18}O$ C_{10} /$OC_{10}H_{18}$ / OH_{18} C_{10} **IGNORE** $C_9H_{17}CHO$ and other structural formulae as working **COMMENT** Allow numbers not as subscripts e.g.C10H18O Structural formula without correct molecular formula will not score.	superscripts	**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)	 Circle as shown **ALLOW** * or any other clear indication of the correct carbon atom	more than one carbon atom indicated	**1**

Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	**Stand alone marks** **First mark** restricted / barrier to rotation around/due to C=C/∏ bond **ALLOW** no/lack of/inhibits (free) rotation around/due to C=C/∏ bond **(1)** **Second mark** two different atoms/groups attached to each C in C=C /each C in C=C must not have two groups the same attached to it **OR** 4 different atoms/groups attached to C=C **ALLOW** 2 highest priority/molecular mass/atomic number atoms/groups on opposite sides (of C=C) is the *E* isomer **ALLOW** 2 highest priority/molecular mass/atomic number atoms/groups on the same side (of C=C) is the *Z* isomer **ALLOW** correct diagrams to show any of these points **(1)**	Just 'no rotation' without reference to C=C molecule does not rotate molecules/compounds attached to C atoms	**2**

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	circle around double bond as shown  **ALLOW** any clear indication of the correct double bond or a circle around **either** of the two carbon atoms in this bond. **ALLOW** the circle being extended to the adjacent carbon atoms attached to the C=C.	both C=C bonds circled the circle extended to include the C=O and/or C-H bond(s) on the right	**1**

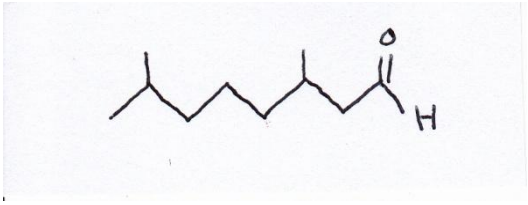
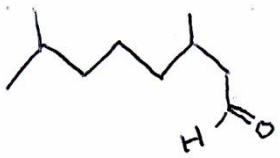
<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>18(d)</td><td>Any reagent (1)
and matching observation (1)
from

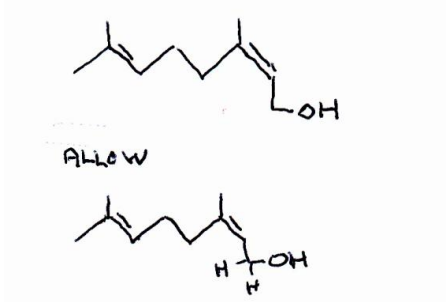
<table>
<tr><th>reagent</th><th>observation</th></tr>
<tr><td>Fehling’s (solution and heat/boil)</td><td>(blue solution) to red / red-brown/brown /orange
and precipitate</td></tr>
<tr><td>Benedict’s (solution and heat/boil)</td><td>(blue solution) to red / red-brown/brown /orange
and precipitate</td></tr>
<tr><td>Tollens’ (reagent) /ammoniacal silver nitrate
(and warm)</td><td>silver mirror
or
grey/black/silver and ppt</td></tr>
<tr><td>ALLOW
potassium/sodium dichromate((VI))
and sulfuric acid
(and warm)
or
acidified dichromate((VI) ions and warm)
or acidified (potassium/sodium) dichromate((VI))</td><td>(orange) to green/blue</td></tr>
<tr><td>ALLOW
Schiff’s reagent</td><td>pink/purple/magenta</td></tr>
</table>

ALLOW correct formulae/ names

IGNORE Brady’s reagent/2,4- DNPH etc

IGNORE sodium hydroxide in Tollens’ reagent</td><td>Just an observation not linked to a reagent</td><td>2</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
18(e)(i)	In (e)(i) and (e)(ii), penalise any structure other than skeletal only once, in the item where it appears first  **OR**  **ALLOW** any unambiguous skeletal formula showing the aldehyde (with or without the H in CHO)	any structure with an OH group	**1**

Question Number	Acceptable Answers	Reject	Mark
18(e)(ii)	In (e)(i) and (e)(ii), penalise any structure other than skeletal only once, in the item where it appears first  **ALLOW** O^- for OH **ALLOW** –O-H for OH **ALLOW** the OH on either side of the structure **ALLOW** just 1 H shown on the C with the OH attached **ALLOW** any unambiguous skeletal formula showing the alcohol (with or without the 2Hs on end C)	any structure without both C=C the *E* isomer	**1**

(Total for Question 18 = 9 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	**First marking point - Orders** H_2O_2 first/1st order/order 1 H^+ zero/0 order/order 0 **both** correct **(1)** **Explanations** **Second marking point** H_2O_2 - as $[H_2O_2]$ doubles **and** $[H^+]$ and $[I^-]$ stay the same/other concentrations stay the same/using experiments 1 and 2 (this could be shown on the table) **and** the rate doubles/working to show this **ALLOW** reverse argument ie as $[H_2O_2]$ halves **and** $[H^+]$ and $[I^-]$ stay the same/other concentrations stay the same/using experiments 1 and 2 (this could be shown on the table) **and** the rate halves/working to show this **(1)** **Third marking point** H^+ - as $[H^+]$ doubles/halves **and** $[H_2O_2]$ and $[I^-]$ stay the same/other concentrations stay the same/using experiments 1 and 3 (this could be shown on the table) **Note** – do not penalise omission of this if it has been penalised in second marking point **and** the rate stays the same /working to show this **OR** As $[H^+]$ doubles **and** $[H_2O_2]$ halves **and** $[I^-]$ stays the same /using experiments 2 and 3 (this could be shown on the table) (also see note above) **and** rate halves due to $[H_2O_2]$ change so rate does not change due to $[H^+]$/working to show this **ALLOW** reverse argument **(1)**	Either/both explanations if inconsistent with order(s) stated above	**3**

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	**First marking point** First/1st order /order 1 **(1)** **Second marking point-consequential on correct order** graph shows rate is (directly) proportional to $[I^-]$ **OR** as $[I^-]$ increases, the rate increases proportionally **OR** as $[I^-]$ doubles, the rate doubles **ALLOW** graph (of rate against $[I^-]$) is a straight line (through the origin) /gradient is constant **ALLOW** Increase in rate is constant **(1)**	Any other order scores zero overall iodine/I_2 Penalise once only in (ii) and (iii)	**2**

Question Number	Acceptable Answers	Reject	Mark
19(a) (iii)	rate/r/R = $k[H_2O_2][I^-]$ **ALLOW** $[H_2O_2]^1[I^-]^1$ **ALLOW** $[H^+]^0$ **ALLOW** upper case K **consequential** on their orders from (a)(i) and (ii)	$[I_2]$	**1**

Question Number	Acceptable Answers	Reject	Mark
19(a) (iv)	2.8×10^{-5} **(1)** $dm^3mol^{-1}s^{-1}$ **(1)** **ALLOW** units in any order **Note:** value and units are consequential on their rate equation from (a)(iii) and must be consistent Ignore SF unless 1. **Comment** If zero order wrt $[I^-]$, $k = 1.4 \times 10^{-5}\ s^{-1}$		**2**

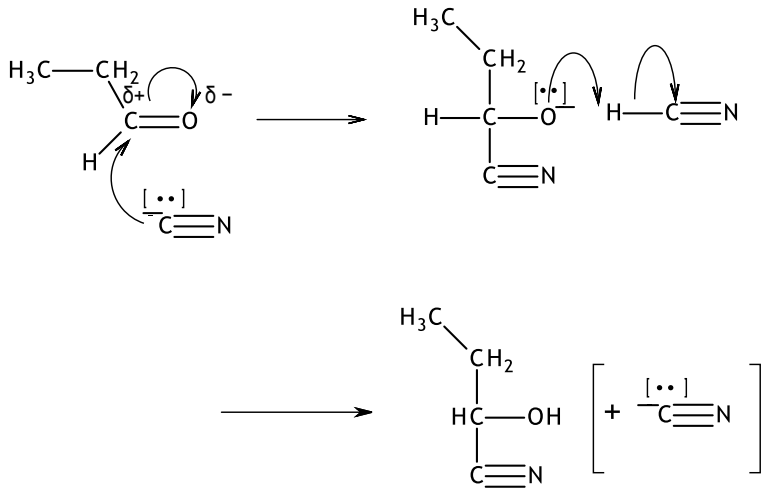
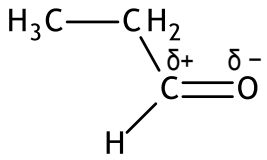
Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	(Rate determining step) Any balanced equation that has just **$2NO_2$** on the LHS **(1)** (Step 2) Any balanced equation for which the two steps combine to the overall equation/double the overall equation **(1)** **Examples of matching pairs:** $2NO_2 \rightarrow N_2O_4$ $N_2O_4 + CO \rightarrow NO + NO_2 + CO_2$/ $N_2O_4 + 2CO \rightarrow 2NO + 2CO_2$ **OR** $2NO_2 \rightarrow 2NO + O_2$ $2CO + O_2 \rightarrow 2CO_2$/$CO + 1/2O_2 \rightarrow CO_2$ **OR** $2NO_2 \rightarrow N_2 + 2O_2$ $N_2 + 2O_2 + CO \rightarrow NO + NO_2 + CO_2$ **OR** $2NO_2 \rightarrow 2NO + 2O$ $NO + 2O + CO \rightarrow NO_2 + CO_2$ **OR** $2NO_2 \rightarrow NO + NO_3$ $2CO + NO_3 \rightarrow 2CO_2 + NO$ **ALLOW** $NO_2 + NO_2$ on LHS **NOTE** $NO_2 \rightarrow NO + 1/2O_2$ then $CO + 1/2O_2 \rightarrow CO_2$ Does not score the first mark but scores 1 for the consequential second equation **IGNORE** state symbols even if incorrect	NO_2 or any multiple other than 2 of NO_2 on LHS for first mark only	**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	In (b)(ii) penalise incorrect/missing units but allow J/mol K and J/mol/K and lower case k **FIRST CHECK THE FINAL ANSWER,** If answer is -13.3 J mol^{-1} K^{-1} or -0.0133 kJ mol^{-1} K^{-1}, award **2** marks 13.3 J mol^{-1} K^{-1} /0.0133 kJ mol^{-1} K^{-1} (sign omitted) **(1)** -13.3 / -0.0133 (units omitted) **(1)** If none of the above answers is given **First mark** for correct data used **(1)** **Second mark** value, sign and units consequential on incorrect entropy value(s) used in the correct expression (ΔS^{o}_{system} =) [210.7 + 213.6] – [197.6 + 240.0] **(1)** **IGNORE** SF except 1SF		**2**

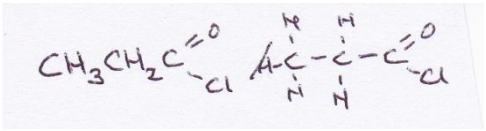
Question Number	Acceptable Answers	Reject	Mark
19(b)(iii)	**FIRST CHECK THE FINAL ANSWER,** If final answer is +0.75839 kJ mol^{-1} K^{-1} **(2)** +758.39 J mol^{-1} K^{-1} **(2)** **EITHER** ($\Delta S^{\ominus}_{surroundings}$ =) $\frac{-\Delta H}{T}$ OR $-\frac{(-226)}{298}$ **(1)** = 0.75839 kJ mol^{-1} K^{-1} **(1)** Second mark is for answer with correct unit **OR** ($\Delta S^{\ominus}_{surroundings}$ =) $\frac{-\Delta H}{T}$ OR $\frac{-(-226000)}{298}$ **(1)** = 758.39 J mol^{-1} K^{-1} **(1)** Second mark is for answer with correct unit **ALLOW** -0.75839 kJ mol^{-1} K^{-1} /-758.39 J mol^{-1} K^{-1} **(1)** **IGNORE** SF except 1 SF	-0.75839 / -758.39 with no units	**2**

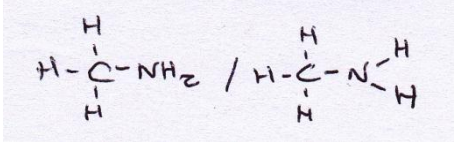
Question Number	Acceptable Answers	Reject	Mark
19(b)(iv)	**First marking point** ($\Delta S^{\ominus}_{total} = \Delta S^{\ominus}_{system} + \Delta S^{\ominus}_{surroundings}$) (= -13.3 + 758.39) / (-0.0133 + 0.75839) =(+)745.09 J K^{-1} mol^{-1}/(+)0.74509 kJ K^{-1} mol^{-1} **(1)** **TE** on (ii) and (iii) added together with the same units **IGNORE** SF except 1 SF **IGNORE** units, even if incorrect **Second marking point** (sign is positive so) reaction is (thermodynamically) feasible / spontaneous **(1)** **ALLOW** feasible / will occur / reaction goes / it reacts (at 298 K) reactants thermodynamically unstable **COMMENT** If value for $\Delta S^{\ominus}_{total}$ is negative, then allow consequential mark for (sign is negative so) reaction is not feasible / not spontaneous / will not occur / reaction / it does not take place (at 298 K)	(ii) and (iii) added together with different units for first mark only	**2**

(Total for Question 19 = 16 marks)

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	 **Lone pairs are not needed** **Allow** C_2H_5 **First mark** dipole on C=O  **(1)** **Second mark** arrow from anywhere on CN^- to carbon of C=O/space between the CN^- and carbon of C=O **and** arrow from C=O bond to O **ALLOW** CN^- without showing the triple bond/charge anywhere on CN **ALLOW** arrow from C=O bond to O to show the formation of charged canonical form (C^+-O^-) followed by attack of CN^- **(1)** **Third mark** correct intermediate with full negative charge **(1)** **Fourth mark** arrow from oxygen to H **and** from H-CN bond to C of CN **ALLOW** arrow from oxygen to H^+ **ALLOW** arrow from oxygen to H of H_2O **and** from H-OH bond to OH **(1)**	Penalise incorrect number of C atoms in propanal once only Full charges Half arrows starting from KCN/HCN /$CN^{\delta-}$ ..C-NC bond	**4**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	nucleophilic **(1)** addition **(1)** **Note** Do not allow 'addition' if S_N1/ S_N2 are included in the answer. Words can be in either order		**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	If name and formula given, both must be correct CH_3CH_2COCl / propanoyl chloride /  **ALLOW** skeletal formula/any combination of displayed/structural formula **Ignore** C_3H_5OCl **Comment** Molecular formula without correct structural formula or name will not score.		**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	If name and formula given, both must be correct methylamine / CH_3NH_2 / NH_2CH_3  **Ignore** CH_5N/ CNH_5 **Note** Allow the mark if the answer to this item is written by Step 3 in the flow chart on page 19	methyl amide	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	4/four (peaks)		**1**

Question Number	Acceptable Answers	Reject	Mark
20(c)	$CH_3CH_2COOH + CH_3CH(OH)CH_3 \rightleftharpoons CH_3CH_2COOCH(CH_3)_2 + H_2O$ $CH_3CH_2COOCH(CH_3)_2$ **(1)** rest of equation correct including H_2O, conditional on correct structure for ester **(1)** **ALLOW** full displayed formulae or a combination of structural and displayed formulae **ALLOW** missing bracket around OH **ALLOW** $\rightarrow$ instead of $\rightleftharpoons$ **ALLOW** H^+ above the arrow or eqm sign OR on both sides of the equation. **Note:** If candidate uses propan-1-ol/C_3H_7OH allow 1 mark for a completely correct equation $CH_3CH_2COOH + CH_3CH_2CH_2OH \rightleftharpoons CH_3CH_2COOCH_2CH_2CH_3 + H_2O$ **OR** $CH_3CH_2COOH + C_3H_7OH \rightleftharpoons CH_3CH_2COOCH_2CH_2CH_3 + H_2O$	molecular formulae penalise missing H once only any other alcohol or acid used for both marks	**2**

Question Number	Acceptable Answers	Reject	Mark
20(d)	**First marking point** propan-1-ol/correct structural/displayed/skeletal formula/ **ALLOW** propanol **and** primary alcohol /1^{o}/1^{y} **ALLOW** C_3H_7OH **(1)** **Second marking point – stand alone** because the IR spectrum shows an absorption at 3750-3100 (cm^{-1}) due to the OH bond/OH group /alcohol/hydroxy(l) **OR** no peak at around 1700 / 2700-2775 (cm^{-1}) so it is not an aldehyde **(1)** **Note** – these could be shown on the spectrum as labelled peaks **ALLOW** any wavenumber or range within the ranges given above **IGNORE** any other peaks mentioned/references to bend/stretch/intensity	hydroxide	**2**

(Total for Question 20 = 13 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	(K_p =) $\frac{P^2_{HI}}{P_{H_2} \times P_{I_2}}$ **ALLOW** P_{HI}^2 **ALLOW** lower or upper case p /pp/curved brackets **IGNORE** state symbols even if incorrect **IGNORE** missing x	square brackets expressions without p/pp/P/PP to show partial pressure	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)* (ii)			**5**

	H_2	I_2	2HI
initial mol	1	1	0
eqm mol	0.21	0.21	1.58
partial pressure	$\frac{0.21 \times 5}{2} = 0.525$	$\frac{0.21 \times 5}{2} = 0.525$	$\frac{1.58 \times 5}{2} = 3.95$
K_p	$\frac{3.95^2}{0.525^2}$ = 56.6/57 no units		

First mark
eqm mol of H_2 = 0.21 **(1)**

Second mark
eqm mol of HI = 1.58 (**see note at end)** **(1)**

Third mark
all 3 partial pressures, either working or answer **(1)**
consequential on their equilibrium moles

Fourth mark
correct value (56.6/57) for K_p with or without working **(1)**

consequential on their partial pressures and their expression for K_p in (a)(i)

Fifth mark
'no units' stated / working to show that units cancel / statement that units cancel
ALLOW - $/atm^0$ or similar indication of no units
ALLOW units based on expression for K_p in (i) or the expression they have used in the calculation in (ii) **(1)**

Note
Only award 5 marks if partial pressures are stated or working to show them
If 0.21 mol H_2 **(1)** and 0.79 mol HI**(0)**,
then partial pressures H_2/I_2 = 0.868 and HI = 3.264 **(1)**
K_p = 14/14.2 **(1)** no units **(1)**

If 0.21 mol H_2 **(1)** and 0.42 mol HI**(0)**,
then partial pressures H_2/I_2 = 1.25 and HI = 2.5 **(1)**
K_p = 4 **(1)** no units **(1)**

Alternative method for marks 2 and 3
If initial $P(H_2)$ and $P(I_2)$ = 2.5 (atm)
Eqm $P(H_2)$ and $P(I_2)$ = 2.5x0.21 = 0.525(atm) **(1)**
P(HI) = 5-(2 x 0.525) = 3.95 **(1)**
IGNORE SF except 1SF

Question Number	Acceptable Answers	Reject	Mark
21(b)	No effect because (there are) equal numbers of (gas) mole(cule)s on each side of the equation	Just 'equal numbers of mole(cule)s'	**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	**First mark** (ΔH is negative/exothermic so) $-\Delta H/T$ gets less positive **ALLOW** decreases **OR** (ΔH is negative/exothermic so) $\Delta S_{surroundings}$ gets less positive **ALLOW** decreases **(1)** **Second mark** (so, since $\Delta S_{total} = -\Delta H/T + \Delta S_{system}$) **(1)** ΔS_{total} decreases Mark independently **No** TE on incorrect $\Delta S_{surroundings}$ **Ignore** comments based on K_p		**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)* (ii)	**First mark** $\ln K = \Delta S_{total}/R$ **OR** $K = e^{\Delta S total/R}$ **OR** $\Delta S_{total} = R\ln K$ **OR** ΔS_{total} is (directly) proportional to $\ln K$ **(1)** **Second mark** K_p decreases **and** yield (of HI) decreases **(1)** **consequential** on their ΔS_{total} in (c)(i) **Ignore** comments based on Le Chatelier's principle	ΔS_{total} is (directly) proportional to K Just 'equilibrium position moves to the left' without reference to yield and kp	**2**

(Total for Question 21 = 11 marks)

TOTAL FOR SECTION B = 49 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	Proton donor/donates protons **OR** H^+ ion donor/donates H^+ ions **Ignore** just releases H^+ ions or protons.		**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	$CH_3CH(OH)COOH + H_2O \rightleftharpoons CH_3CH(OH)COO^- + H_3O^+$ **OR** $CH_3CH(OH)CO_2H + H_2O \rightleftharpoons CH_3CH(OH)CO_2^- + H_3O^+$ **ALLOW** $\rightarrow$ for $\rightleftharpoons$ **ALLOW** $CH_3CH(OH)COOH \rightleftharpoons CH_3CH(OH)COO^- + H^+$ **ALLOW** $CH_3CH(OH)CO_2H \rightleftharpoons CH_3CH(OH)CO_2^- + H^+$ **Ignore** state symbols even if incorrect **Ignore** missing bracket around OH	HA and A^- once only in (a)(ii) and (a)(iii) Penalise missing H once only in (a)(ii) and (a)(iii)	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	(K_a =) $\frac{[CH_3CH(OH)COO^-][H_3O^+]}{[CH_3CH(OH)COOH]}$ **OR** $\frac{[CH_3CH(OH)CO_2^-][H_3O^+]}{[CH_3CH(OH)CO_2H]}$ **OR** $\frac{[CH_3CH(OH)COO^-][H^+]}{[CH_3CH(OH)COOH]}$ **OR** $\frac{[CH_3CH(OH)CO_2^-][H^+]}{[CH_3CH(OH)CO_2H]}$ **Note** Allow any of these for the mark, even if a different equation using H^+/H_3O^+ has been given in (a)(ii)	H_2O in expression Lack of square brackets HA and A^- once only in (a)(ii) and (a)(iii) Penalise missing H once only in (a)(ii) and (a)(iii)	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a) (iv)	**Comment Allow** $[H_3O^+]$, $[HA]$, $[A^-]$ as alternative formula throughout **Calculation** **Ignore** sf, except 1 sf, throughout **First** check the final answer If pH = 2.34, award the first **3** marks If pH ≠ 2.34, award marks as follows **ROUTE 1** $K_a = 10^{-3.86} = 1.3804 \times 10^{-4}$(mol dm^{-3}) **(1)** $[H^+] = \sqrt{K_a}[CH_3CH(OH)COOH]$ $= \sqrt{1.38 \times 10^{-4} \times 0.15}$ $= 4.5504 \times 10^{-3}$ (mol dm^{-3}) **(1)** **TE** on their value for K_a $pH = -\log_{10}[H^+] = -\log_{10} 4.55 \times 10^{-3}$ $= 2.3420/2.34$ **(1)** **TE** on their value for $[H^+]$ provided pH>1 and < 7 (pH = 0.12 if use 3.86 for K_a, scores 2) **ROUTE 2** $[H^+] = \sqrt{K_a}[CH_3CH(OH)COOH]$ pH = ½ pK_a – ½ log$[CH_3CH(OH)COOH]$ **(1)** = ½ 3.86 – ½ log 0.15 **(1)** = 2.34 **(1)** **TE** on not halving (4.68 is worth 1 mark) **Assumption 1** $[H^+] = [CH_3CH(OH)COO^-]$ **OR** no H^+ from the (ionization of) water/ionization of water is negligible **OR** H^+ is (only) from the acid **(1)** **Assumption 2** Ionization/dissociation of the (weak) acid is negligible / very small / insignificant **OR** $[CH_3CH(OH)COOH]_{initial} = [CH_3CH(OH)COOH]_{equilibrium}$ **OR** $[CH_3CH(OH)COOH]_{equilibrium} = 0.15$ (mol dm^{-3}) **OR** $[H^+]/ [CH_3CH(OH)COO^-] << [CH_3CH(OH)COOH]$ **OR** $[CH_3CH(OH)COOH]$/acid concentration remains constant **(1)**	Incorrect units for K_a and/or $[H^+]$, max 2 for calculation $[H^+]_{initial} = [H^+]_{equilibrium}$/	**5**

	ROUTE 3 **First** check the final answer If pH = 2.35, award the first **4** marks If pH ≠ 2.35, award marks as follows $K_a = 10^{-3.86} = 1.38 \times 10^{-4}$ (mol dm^{-3}) **(1)** $[H^+]^2 = K_a([CH_3CH(OH)COOH] - [H^+]$ $[H^+]^2 = 1.38 \times 10^{-4} \times (0.15 - [H^+])$ **(1)** $[H^+] = 4.48 \times 10^{-3}$ (mol dm^{-3}) **(1)** **ecf** on their value for K_a $pH = -\log_{10}[H^+]$ $= -\log_{10} 4.48 \times 10^{-3}$ $= 2.35$ **(1)** **TE** on their value for $[H^+]$ **Assumption** $[H^+] = [CH_3CH(OH)COO^-]$ **OR** no H^+ from the (ionisation of) water **OR** H^+ is (only) from the acid **(1)**		$[H^+]_{initial} = [H^+]_{equilibrium}$	

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	If answer is 13.2, with or without working, award 2 marks (13/13.17 score 1 mark, answer not to 1 dp) $[H^+] = \frac{1.0 \times 10^{-14}}{0.15}$ $= 6.67 \times 10^{-14}$ (mol dm^{-3}) **(1)** pH $= -\log_{10} 6.67 \times 10^{-14}$ $= 13.176$ $= 13.2$ **(1)** **TE** on their $[H^+]$, provided pH > 7 and < 14 **OR** pOH = 0.824 **(1)** pH = 14-0.824 = 13.176 = 13.2 **(1)**	Answer not given to 1 dp Answer not given to 1 dp	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Curve continues and finishes at any pH between 12 and 13.2 **ALLOW** this as standalone if they have no pH in (b)(i) or their pH is ≤ 10 **TE** on their pH in (b)(i) if it is › 10	finishing at >13.2 or ‹12 curves that 'dip' by more than 1 small square at the end stopping before 45 cm^3	**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)(iii)	**Indicator and colour change** named indicator **(1)** matching colour change **(1)** phenol red yellow to red/pink **OR** thymol blue (base) yellow to blue **OR** phenolphthalein colourless to red/pink /magenta **ALLOW** bromothymol blue yellow to blue **ALLOW** thymolphthalein if they have continued to vertical section to at least 10.6 with colour change colourless to blue, for both marks **ALLOW** correct colour change for thymolphthalein even if the vertical section does not continue to 10.6 for 1 mark. **NO** TE for colour change from any other indicator **Justification** pH range (of indicator) lies (completely) in the vertical jump (on the titration curve) **OR** Indicator will change colour in the vertical section of the graph **OR** pH range of indicator and pH range of vertical section of the graph stated as long as they overlap **ALLOW** pK_{in} (±1) is in the vertical jump **OR** pK_{in} is nearest to the pH at the end/equivalence point **ALLOW** Indicator will change colour at the end/equivalence point **ALLOW** (because it is a) titration of a weak acid with a strong base **(1)**	Universal indicator loses all 3 marks	**3**

Question Number	Acceptable Answers	Reject	Mark
22(b)(iv)	the concentration of sodium lactate is 0.075 mol dm^{-3} when equal amounts of acid and base have been mixed **OR** (only sodium lactate is present and it is the) pH at the equivalence/end point/ halfway up the vertical section of the curve **ALLOW** explanation or an equation to show that lactate ions react with water to produce an alkaline solution **(1)** any number or range within 7.5 – 9.5 **(1)**	pH of buffer solution 7/7.0	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)* (v)	**Comment Allow** [HA], [A^-] as alternative formulae throughout **First mark – statement or equations showing the buffer solution** buffer solution contains a large amount/reservoir /excess of a weak acid and its conjugate base/salt **OR** a large amount/reservoir /excess of lactic acid and lactate ions/formulae for lactic acid and lactate ions **OR** $CH_3CH(OH)COOH \rightleftharpoons CH_3CH(OH)COO^- + H^+$ / $CH_3CH(OH)COOH + H_2O \rightleftharpoons CH_3CH(OH)COO^- + H_3O^+$ **and** $CH_3CH(OH)COO^{(-)}Na^{(+)} \rightarrow CH_3CH(OH)COO^- + Na^+$ **Ignore** definitions of a buffer solution **(1)** **Second mark – identifying which species react with the added acid and alkali** $CH_3CH(OH)COOH$ reacts with added alkali/OH^- ions OR $CH_3CH(OH)COOH + OH^- \rightarrow$ OR OH^- ions react with H^+/H_3O^+ ions **and** $CH_3CH(OH)COO^-$ reacts with added acid/H^+ ions / H_3O^+ ions OR $CH_3CH(OH)COO^- + H^+/ H_3O^+ \rightarrow$ **OR** $(pH = pK_a + \lg\frac{[salt]}{[acid]})$ small additions of acid/alkali have little/no effect on $\lg\frac{[salt]}{[acid]}$ so pH hardly changes/no change **ALLOW** Ratio [acid]:[salt]/[salt]:[acid] only changes a little so pH hardly changes/no change **ALLOW** HA and A^- in formulae/equations **(1)** **Comment** This mark may be given from the equations	Reservoir of H^+ ions $\rightarrow$ in equation $\rightleftharpoons$ in equation	**4**

	Third mark – ionic equation for OH^- **ALLOW** equations with reversible arrows $CH_3CH(OH)COOH + OH^- \rightarrow CH_3CH(OH)COO^- + H_2O$ **ALLOW** $H^+ + OH^- \rightarrow H_2O$ / $H_3O^+ + OH^- \rightarrow 2H_2O$ **(1)** **Fourth mark – ionic equation for H^+** $CH_3CH(OH)COO^- + H^+ \rightarrow CH_3CH(OH)COOH$ **OR** $CH_3CH(OH)COO^- + H_3O^+ \rightarrow CH_3CH(OH)COOH + H_2O$ **(1)** **Note** Only penalise non ionic equations e.g. using NaOH, HCl once only. **Comment** Two completely correct ionic equations scores marks 2,3 and 4		

Question Number	Acceptable Answers	Reject	Mark
22(c)	$CH_3CH(OH)COO^-$ + $CH_3COOH_2^+$ **both** needed for the mark **ALLOW** $[CH_3CH(OH)COO]^-$ + $[CH_3COOH_2]^+$ **ALLOW** $[CH_3COOHH]^+$ / CH_3COOHH^+ for the ethanoic acid ion $CH_3CH(OH)CO_2^-$ for the lactic acid ion		**1**

(Total for Question 22 = 21 marks)

TOTAL FOR PAPER = 90 marks