



Mark Scheme (Results)

June 2014

GCE Chemistry (6CH04/01R)

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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 (a)	D		1

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

Question Number	Correct Answer	Reject	Mark
1 (c)	A		1

Question Number	Correct Answer	Reject	Mark
1 (d)	C		1

Question Number	Correct Answer	Reject	Mark
1 (e)	B		1

Question Number	Correct Answer	Reject	Mark
2(a)	A		1

Question Number	Correct Answer	Reject	Mark
2 (b)	B		1

Question Number	Correct Answer	Reject	Mark
2 (c)	D		1

2 (d)	C		1
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Question Number	Correct Answer	Reject	Mark
3	A		1

Question Number	Correct Answer	Reject	Mark
4 (a)	C		1

Question Number	Correct Answer	Reject	Mark
4 (b)	B		1

Question Number	Correct Answer	Reject	Mark
4 (c)	C		1

Question Number	Correct Answer	Reject	Mark
5	C		1

Question Number	Correct Answer	Reject	Mark
6(a)	B		1

Question number	Correct Answer	Rejecct	Mark
6 (b)	D		1

Question Number	Correct Answer	Reject	Mark
6 (c)	D		1

Question Number	Correct Answer	Reject	Mark
6 (d)	A		1

Question Number	Correct Answer	Reject	Mark
7(a)	C		1

Question Number	Correct Answer	Reject	Mark
7 (b)	D		1

Section A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
8(a)(i)	+104.6 – [+41.4 +165] (1)		2
	= -101.8 J mol ⁻¹ K ⁻¹		
	Value, sign and unit (1)		
	Ignore SF except one		
	Internal TE allowed for recognisable numbers, for example: ΔH_{at} calcium instead of S° (178.2 → -238.6)		
	OR Halving S° [Cl ₂] (82.5 → -19.3)		
Correct answer with no working (2)			
+/no sign 101.8 J mol ⁻¹ K ⁻¹ (1)			

Question Number	Acceptable Answers	Reject	Mark
8 (a) (ii)	<p>(The sign is negative because)</p> <p>Any two from:</p> <ul style="list-style-type: none"> • (A solid and) a gas reacting to form a solid. <p>OR</p> <p>(Entropy decreases because) a gas reacting to form a solid.</p> <ul style="list-style-type: none"> • There are fewer ways of arranging particles in a solid than a gas or vice-versa. <p>OR</p> <p>Decrease in disorder as solid more ordered than gas or vice versa</p> <ul style="list-style-type: none"> • Two mol(es) of reactant forming one mole of product. (Ignore two molecules form one molecule) <p>OR</p> <p>Number of mol(es)/molecules decreases</p> <p>OR</p> <p>Fewer/less mol(es) of products than reactants</p> <p>COMMENT</p> <p>If answer to (a)(i) is positive then answer should start</p> <p>'Answer is not as expected because...'</p> <p>Then score as above (which can score full marks).</p>	<p>Energy...</p> <p>'(Positive) Answer is as expected...'</p>	2

Question Number	Correct Answer	Reject	Mark
8 (b)	$\Delta S^{\circ}_{\text{total}} = \Delta S^{\circ}_{\text{surroundings}} + \Delta S^{\circ}_{\text{system}}$ <p>OR</p> $= +2670 + (-101.8)$ $= (+)2568.2$ <p>Value 2568.2/2568 (1)</p> $= (+)2570 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ <p>3SF</p> <p>This mark is conditional on correct value or correct TE value from (a)(i) (1)</p> <p>Accept TE from (a)(i)</p> <p>-238.6 → +2431.4 → +2430</p> <p>-19.3 → 2650.7 → +2650</p> <p>Correct answer (2570, etc) with or without working scores (2)</p>		2

Question Number	Correct Answer1	Reject	Mark
8 (c)	$\Delta S^{\circ}_{\text{surroundings}} = - \frac{\Delta H^{\circ}}{298}$ $\Delta H^{\circ} = - \Delta S^{\circ}_{\text{surroundings}} \times 298$ <p>OR</p> $= -2670 \times 298$ <p style="text-align: right;">(1)</p> $= -795.660$ $= -795.7 \text{ (kJ mol}^{-1}\text{)}$ <p style="text-align: right;">(1)</p> <p>ALLOW</p> $= -795.7 \times 10^3 \text{ J mol}^{-1}$ <p>Note</p> <p>1. $-796 = -796.1964$ (if 2570 used to calculate entropy change of surroundings first.)</p> <p>2. $\Delta H^{\circ} (= + \Delta S^{\circ}_{\text{surroundings}} \times 298)$</p> $= +795.7 \text{ (kJ mol}^{-1}\text{)}$ <p style="text-align: right;">(1)</p> <p>But</p> $\Delta H^{\circ} = - \frac{\Delta S^{\circ}_{\text{surroundings}}}{298}$ <p style="text-align: right;">(0)</p> <p>Ignore SF except one</p>		2

Question Number	Correct Answer	Reject	Mark
8 (d) (i)	$50 \times 4.2 \times 15.0$ = 3150 (J) Ignore sign ALLOW 3.15 kJ Ignore SF except one		1

Question Number	Correct Answer	Reject	Mark
8 (d) (ii)	$3150/0.05$ or 20×3150 = -63 (kJ mol ⁻¹) /-63000 J mol⁻¹ Allow TE answer (d)(i) / 0.05 Ignore SF except one Value (1) Sign (1) The mark for the negative sign is awarded for the calculation even if the value is wrong, providing any energy divided by moles or energy multiplied by 1/number of moles calculation has been done.		2

Question Number	Correct Answer	Reject	Mark
*8 (d) (iii)	<p>The correct answer:</p> <p>-380.5/-381 kJ mol⁻¹</p> <p>Full marks with or without correct working.</p> <p>First mark</p> <p>Appreciation of Hess's Law either in words, numbers, symbols or on the diagram</p> <p>For example,</p> $\Delta H_{\text{solution}} + \text{Lattice energy}$ $= \Delta H_{\text{hydration}} \text{Ca}^{2+} + (2)\Delta H_{\text{hydration}} \text{Cl}^{-}$ <p style="text-align: right;">(1)</p> <p>Second mark</p> $2 \Delta H_{\text{hydration}} \text{Cl}^{-} = -2258 - 63 - (-1560) = -761$ <p>ALLOW</p> <p>Any number or group of numbers minus (-1560)</p> <p style="text-align: right;">(1)</p> <p>Third mark</p> $\Delta H_{\text{hydration}} \text{Cl}^{-} = -380.5/-381 \text{ (kJ mol}^{-1}\text{)}$ <p>Any number, wherever it has come from, divided by two can score this mark, provided that the sign is consistent.</p> <p style="text-align: right;">(1)</p> <p>Ignore SF except one</p> <p>Use of lattice energy – 2223 gives –363 scores</p> <p style="text-align: right;">(2)</p> <p>ALLOW</p> <p>TE from (d)(ii)</p>		3

Question Number	Correct Answer	Reject	Mark
8(d)(v)	<p>Both marks may be awarded in either part.</p> <p>First mark</p> <p>(Temperature increases) because the reaction/process/dissolving/hydration of ions is exothermic.</p> <p>OR</p> <p>Strong(er) forces between the δ^+ H and Cl^-</p> <p>OR</p> <p>Strong(er) forces between the δ^- O and Mg^{2+}</p> <p>OR</p> <p>Strong(er) ion-dipole forces</p> <p>OR</p> <p>Formation of bonds releases energy</p> <p>OR</p> <p>Strong(er) bonds formed</p> <p>OR</p> <p>Enthalpy of hydration is greater than lattice energy</p> <p style="text-align: right;">(1)</p> <p>Second mark</p> <p>(Volume decreases so) shorter bonds between ion and water molecules</p> <p>ALLOW</p> <p>Water molecules more tightly arranged/pack better/occupy less space</p> <p>OR</p> <p>Water molecules more ordered/ clustered (around the ions).</p> <p style="text-align: right;">(1)</p>	<p>The breaking of the lattice is exothermic.</p> <p>Ions more tightly arranged</p> <p>Ions more ordered</p>	2

Total 18 marks

Question Number	Correct Answer	Reject	Mark
9 (a) (i)	<p>Sodium/potassium dichromate ((VI)) and (Dilute/concentrated) sulfuric acid</p> <p>OR</p> <p>correct formulae / H^+ and $Cr_2O_7^{2-}$</p> <p>ALLOW</p> <p>H^+ and $Cr_2O_7^{2-}$/acidified dichromate((VI))</p> <p style="text-align: right;">(1)</p> <p>Reflux/distil</p> <p>Ignore 'heat', 'warm', and 'boil' alone.</p> <p>ALLOW</p> <p>Just 'under reflux'</p> <p>Just 'under distillation'</p> <p style="text-align: right;">(1)</p> <p>Second mark depends on mention of dichromate/$Cr_2O_7^{2-}$ in first part</p> <p>OR</p> <p>$KMnO_4$ and acid with heat</p> <p style="text-align: right;">(1)</p>	Hydrochloric acid	2

Question Number	Correct Answer	Reject	Mark
9 (a) (ii)	<p>Carbonyl group – addition of 2,4-dinitrophenylhydrazine / 2,4-DNP(H) / Brady's reagent (1)</p> <p>to give yellow/orange/red precipitate/ppt/ppte/solid/crystals</p> <p>ALLOW</p> <p>recognisable spelling e.g., percepitate (1)</p> <p>CH₃C=O reaction with iodine in alkali/NaOH/KOH/OH⁻</p> <p>ALLOW</p> <p>Iodoform/tri-iodomethane/haloform</p> <p>AND</p> <p>reaction/test (1)</p> <p>to form (pale) yellow / cloudy precipitate/solid/crystals (1)</p> <p>Ignore references to smell</p> <p>Ignore heat in either part</p> <p>Note</p> <ul style="list-style-type: none"> In both cases result mark depends on test being recognisably correct even if it did not score a mark <p>Examples:</p> <p>DNP gives yellow ppt</p> <p>Iodine test gives yellow ppt</p> <p>Tests for aldehydes with correct results, no marks</p>	<p>2-DNP/4DNP</p> <p>Just DNP</p> <p>Brick red ppt</p>	4

Question Number	Correct Answer	Reject	Mark
9 (b) (i)	<p>Arrow (from carbon) of CN^- to carbon of $\text{C}=\text{O}$</p> <p>AND</p> <p>Arrow from part of $\text{C}=\text{O}$ double bond to oxygen</p> <p>ALLOW</p> <p>Two steps via a charged canonical form (1)</p> <p>Intermediate anion with $\text{C}-\text{CN}$ bond. (1)</p> <p>Arrow from resulting O^- to hydrogen of $\text{HCN}/\text{H}^+/\text{H}_2\text{O}$ (1)</p> <p>Note</p> <p>Arrow directions must be correct to score each mark</p> <p>Penalise half-headed arrows each time in both parts</p> <p>ALLOW skeletal formulae.</p>	<p>CN without negative charge</p> <p>...$\text{C}-\text{NC}$ bond</p>	3

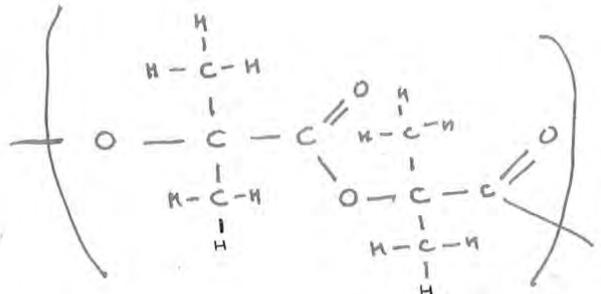
Question Number	Correct Answer	Reject	Mark
9 (c) (ii)	<p>The O-H absorptions for alcohol and carboxylic acid overlap.</p> <p>OR</p> <p>OH absorption for an acid is very broad</p> <p>OR</p> <p>Quote data booklet values which must show some overlap, to include 3300 to 3200.</p> <p>ALLOW</p> <p>OH absorptions similar/the same.</p>	<p>Just 'both have OH groups'</p> <p>Just 'two OH groups present'</p>	1

Question Number	Correct Answer	Reject	Mark
9 (c) (iii)	<p>(Chemical shift) 2.0 - 4.0 (ppm) / any value within this range e.g 3.1/ 3.12/3 ALLOW</p> <p>Correct number followed by ,</p> <p>eg 3δ</p>		1

Question Number	Correct Answer	Reject	Mark
9(c) (iv)	3 (peaks) / three		1

Question Number	Correct Answer	Reject	Mark
9 (c) (v)	<p>There is no hydrogen atom/proton on the adjacent/neighbouring carbon atom</p> <p>ALLOW</p> <p>No adjacent/neighbouring hydrogens/protons</p>		1

Question Number	Correct Answer	Reject	Mark
9 (c) (vi)	(No) 2-hydroxy-2-methylpropanoic acid does not have a chiral centre OR It is not chiral OR It does not have a mirror image which is non-superimposable OR Does not have a carbon atom attached to four different groups	Yes...	1

Question Number	Correct Answer	Reject	Mark
9 (d) (i)	 <p>Ester linkage (1)</p> <p>Rest of molecule (1)</p> <p>ALLOW</p> <p>Attached chains as structural formulae</p> <p>Ignore n or other numbers outside bracket</p> <p>COMMENT Check formulae carefully – different carbon frameworks appear.</p>		1

Question Number	Correct Answer	Reject	Mark
9(d)(ii)	Ester		1

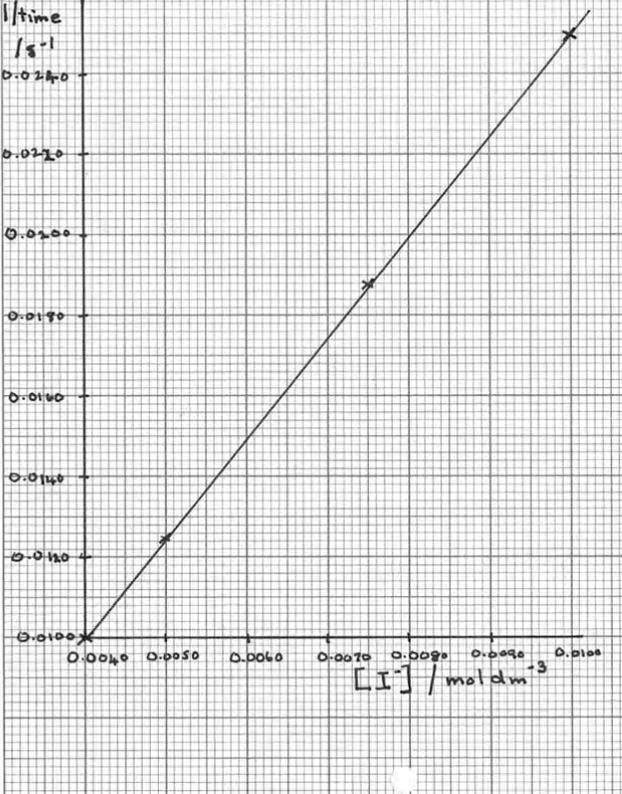
Total 20 marks

Question Number	Correct Answer	Reject	Mark
10(a)	$\text{S}_2\text{O}_8^{2-} + 2\text{I}^- \rightarrow 2\text{SO}_4^{2-} + \text{I}_2$ ALLOW multiples Ignore state symbols even if incorrect COMMENT 2 in front of sulfate is often missed.		1

Question Number	Correct Answer	Reject	Mark
10 (b)(i)	Blue/black /blue-black OR Colourless to blue-black/ blue/black	purple	1

Question Number	Correct Answer	Reject	Mark
10 (b)(ii)	The mixture would change colour/ go blue/black /blue-black immediately/straight away ALLOW ...too quick(ly)/too early ...quicker ...no time delay		1

Question Number	Correct Answer	Reject	Mark
10 (b)(iii)	(As quickly as iodide reacts to form iodine it is) reduced/turned back to iodide by the thiosulfate ions ALLOW Persulfate reacts with thiosulfate first. OR Iodine reacts with thiosulfate.		1

Question Number	Correct Answer	Reject	Mark
10 (c) (i)	 <p>First mark Correct graph of rate v concentration, with axes correct and values increasing on both axes labelled with quantity and units</p> <p>Note Units may be given in brackets with no slash. s/t meaning s divided by time is fine. (1)</p> <p>Second mark Sensible scales to use at least half the graph paper but allow graphs starting at the origin and points cover two by two big squares.</p> <p>Linear scales</p> <p>All points reasonably correct with straight line drawn (1)</p> <p>Second mark depends on correct graph of rate v concentration, but not other detail of first mark</p>		2

Question Number	Correct Answer	Reject	Mark
10 (c)(ii)	<p>First order</p> <p>This mark is independent of the graph drawn</p> <p style="text-align: right;">(1)</p> <p>Because the graph is a straight line (through the origin)/ rate is proportional to $[I^-]$</p> <p>OR</p> <p>As concentration increases by (factor of) 2 rate increases by 2 (or any other numbers, including 'x')</p> <p>OR</p> <p>Rate increases linearly (with concentration)</p> <p>OR</p> <p>Gradient of line is constant</p> <p style="text-align: right;">(1)</p> <p>Second mark depends on first order</p>	Just 'as concentration increases rate increases'	2

Question Number	Correct Answer	Reject	Mark
10 (c)(iii)	<p>Rate = $k[S_2O_8^{2-}][I^-]$</p> <p style="text-align: right;">(1)</p> <p>Units - $dm^3 mol^{-1} s^{-1}$</p> <p>(1)</p> <p>TE from (c)(ii)</p> <p>ALLOW</p> <p>Units in any order</p> <p>Internal TE from rate equation</p>	Incorrect formulae	2

Question Number	Correct Answer	Reject	Mark
10 (d)(i)	<p>Method 1</p> <p>First mark</p> <p style="padding-left: 40px;">Gradient = $- E_a/R$</p> <p>OR</p> <p style="padding-left: 40px;">$E_a = - R \times \text{gradient}$ (1)</p> <p>Second mark</p> <p style="padding-left: 40px;">(Gradient =) $\frac{-3.15 - (-3.84)}{(3.20 - 3.31) \times 10^{-3}}$</p> <p>OR</p> <p style="padding-left: 80px;">= -6272.7 (K)</p> <p>Please award this mark if -6272.7 is seen anywhere! (1)</p> <p>Method 2</p> <p>First mark</p> <p>Setting up two simultaneous equations (1)</p> <p>Second mark</p> <p>Subtracting one equation from the other or other correct methods of solution (1)</p> <p>Third mark (applies to both methods)</p> <p style="padding-left: 40px;">$(E_a) = +52126 \text{ J mol}^{-1}$ $\quad \quad \quad / +52.1(26) \text{ kJ mol}^{-1}$</p> <p>Note: TE can only be given if either method 1 or method 2 has been clearly carried out.</p> <p>Positive sign given</p> <p>OR</p> <p>Two negative signs clearly cancel in method and no sign given (1)</p> <p>Correct answer with or without working, with sign and units (3)</p> <p>Ignore SF unless only one</p>	Negative sign	3

Question Number	Correct Answer	Reject	Mark
10 (d)(ii)	Either Take readings at different temperatures OR Repeat at the same two temperatures ALLOW Just 'repeat the experiment'		1

Total 14 marks

Section B = 52 marks

Section C

Question Number	Correct Answer	Reject	Mark
11(a)(i)	Purple gas/ gas turns colourless <div style="text-align: right;">(1)</div> to (silver/shiny) grey/black solid <div style="text-align: right;">(1)</div> Just gas to solid OR solid forming (1)max	Purple liquid/solid	2

Question Number	Correct Answer	Reject	Mark
11(a)(ii)	First mark Heat for different lengths of time OR After more time/specified time eg 2 days OR Use a colorimeter OR Set up reverse reaction <div style="text-align: right;">(1)</div> Second mark Measure the concentration of a reactant or product of two tubes, which should be the same OR Colour does not change /is same <div style="text-align: right;">(1)</div>		2

Question Number	Correct Answer	Reject	Mark
11 (b) (iii)	$K_c = \frac{0.00048 \times 0.00048}{0.00353^2}$ $= 0.018489$ $= 0.0185$ <p>Allow all SF except 1</p>		1

Question Number	Correct Answer	Reject	Mark
11 (b) (iv)	<p>The units cancel</p> <p>OR</p> <p>There are the same numbers of moles of reactants and products</p>		1

Question Number	Correct Answer	Reject	Mark
11 (c) (i)	$K_c' = \frac{[H_2]^{1/2}[I_2]^{1/2}}{[HI]}$ <p>Ignore state symbols unless (aq) or (s)</p> <p>Ignore eq or eqm</p>	<p>p H₂ etc (K_p)</p> <p>but not if already penalised</p>	1

Question Number	Correct Answer	Reject	Mark
11 (c) (ii)	$K_c' = \frac{[0.00048]^{1/2} [0.00048]^{1/2}}{[0.00353]}$ <p>= 0.136</p> <p>Allow all SF except 1</p> <p style="text-align: right;">(1)</p> <p>Which is the square root of the previous value</p> <p>OR</p> $K_c = (K_c')^2$ <p>OR</p> $0.136^2 = 0.0185$ <p style="text-align: right;">(1)</p>		2

Question Number	Correct Answer	Reject	Mark
11 (d)	<p>Frist mark</p> <p>K_p remains unchanged/constant (1)</p> <p>Second mark</p> <p>(when pressure is increased) the quotient/ratio $p_{H_2} : (p_{HI})^2$ becomes less than K_p</p> <p>OR</p> <p>Ratio decreases</p> <p>OR</p> <p>Ratio proportional to $1/P$ (P is total pressure change)</p> <p>ALLOW</p> <p>K_p proportional to $1/P$ (1)</p> <p>Third mark</p> <p>To restore the value of the quotient/ratio to K_p</p> <p>ALLOW</p> <p>To restore K_p</p> <p>And</p> <p>EITHER</p> <p>p_{H_2} increases / p_{HI} decreases (1)</p> <p>OR</p> <p>Equilibrium shifts to the right (1)</p>	K_p decreases for this mark only	3

Total 18 marks

Section C = 18 marks

TOTAL FOR PAPER = 90 MARKS

