

Mark Scheme (Results)
January 2012

GCE Chemistry (6CH04) Paper 01

General Principles of Chemistry I
Rates Equilibria and Further Organic
Chemistry

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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. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

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) | C | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 1(b) | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 2 | D | | 1 |

| 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) | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 5 | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 6 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 7 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 8 | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 9 | A | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 10 (a) | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 10 (b) | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 11 | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 12 | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 13 (a) | C | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 13 (b) | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 14 | B | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 15 | D | | 1 |

| Question Number | Correct Answer | Reject | Mark |
|-----------------|----------------|--------|------|
| 16 | C | | 1 |

TOTAL FOR SECTION A = 20 MARKS

Section B

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|---|----------|
| 17(a) | Orange/yellow and precipitate/ppt or solid or crystals ALLOW orange-red or red-orange for colour | Any other colour alone or in combination, e.g.red | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|----------|
| 17(b) | <p>(Heat with) Benedict's/Fehling's (solution) (1)</p> <p>Ketone/X would remain blue/no change/no reaction (1)</p> <p>Aldehyde/Y would form red/brown and ppt/Cu_2O (1)</p> <p>ALLOW combinations of red or brown with orange</p> <p>OR</p> <p>(Heat with) Tollens' Reagent/ammoniacal silver nitrate (1)</p> <p>Ketone/X remains colourless/no change/no reaction (1)</p> <p>Aldehyde/Y forms a silver mirror or black/grey precipitate/Ag/silver (1)</p> <p>OR</p> <p>(Heat with) acidified dichromate((VI)) (ions) (1)</p> <p>Ketone/X remains orange/no change/no reaction (1)</p> <p>Aldehyde/Y goes green/blue (1) ALLOW <i>answer with acidified or alkaline KMnO_4</i></p> <p>Ketone/X remains purple/pink/no change/no reaction (1)</p> <p>Aldehyde/Y goes colourless (with acid)/goes green (with alkali) (1)</p> <p>Near miss on reagent (e.g. silver nitrate not ammoniacal silver nitrate) observations can score 2</p> <p>ALLOW iodoform test with ketone identified (since X can only be butanone) (Aqueous) sodium hydroxide and iodine (1)</p> <p>Ketone/X forms yellow precipitate/solid/crystals (1)</p> <p>Aldehyde/Y no change/no reaction (1)</p> | <p>Just orange</p> <p>Ppt</p> <p>Just clear</p> | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|---|----------|
| 17(c)(i) | <p>Both $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ And $(\text{CH}_3)_2\text{CHCHO}$</p> <p>ACCEPT displayed or skeletal formulae if structural formulae not given</p> | COH unless shown correctly in a displayed or skeletal formula | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|----------------------|----------|
| 17(c)(ii) | <p>Recrystallization</p> <p>IGNORE solvent</p> | Just crystallization | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|--|--------------------------|----------|
| 17(c)(iii) | <p>Measure melting temperature / point (1)</p> <p>Compare with literature/database / known value (1)</p> <p>Second mark can only be awarded if first mark scored</p> | Just boiling temperature | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--|------|
| 18(a) | <p>Hazard – methanol/alcohol is flammable (1) IGNORE flammability of vegetable/diesel oils</p> <p>Precaution – use electrical heating source/water bath /avoid naked flames (1)</p> <p>OR</p> <p>Hazard – methanol/alcohol is toxic (1)</p> <p>Precaution – Use in well-ventilated area/fume cupboard/store away from children/wear gloves (1)</p> <p>OR</p> <p>Hazard – NaOH/reaction mixture is corrosive /burns (the skin)/damages the eyes (1) IGNORE references to (strong) alkali(ne) Precaution – wear gloves/goggles</p> <p>ALLOW any 2 hazards but the precaution must be associated with the appropriate hazard</p> <p>If the Hazard is not clearly identified but the precaution is appropriate then allow one mark, e.g. "Use of flammable substances so avoid naked flames" = (1) mark</p> | <p>Just volatile</p> <p>Just dangerous /harmful</p> <p>Just irritant</p> | 4 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--|------|
| 18(b) | <p>Any two from:</p> <p>Reuses/reduces waste (vegetable) oil/ lessens need to dispose of (vegetable) oil (1)</p> <p>Could lessen use of (non-renewable/non-sustainable) crude oil/fossil fuels OR vegetable oil/biodiesel/reactants renewable/sustainable (1)</p> <p>Plants grown for vegetable oil could offset some CO₂ emissions (1)</p> <p>IGNORE references to transport/temperature/energy savings cost/profit/high yield/biodegradability/greenhouse gases</p> | <p>Just methanol is renewable</p> <p>Just carbon neutral/just reduces carbon footprint</p> | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--|----------|
| 19(a)(i) | Sodium/potassium dichromate((VI))/potassium manganate ((VII))/Na ₂ Cr ₂ O ₇ /K ₂ Cr ₂ O ₇ /KMnO ₄ IGNORE references to acid | Just Cr ₂ O ₇ ²⁻ / MnO ₄ ⁻ | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|--------|----------|
| 19(a)(ii) | (Heat under) reflux (1) Use excess/sufficient oxidizing agent/reagent named in (a)(i), even if incorrect (1) IGNORE references to (excess) acid Stand alone marks | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|---|-----------------|----------|
| 19(a)(iii) | <p>CH₃CH₂CN/C₂H₅CN (1)</p> <p>ACCEPT displayed or skeletal formulae</p> <p>CH₃CH₂CN + H⁺ + 2H₂O → CH₃CH₂COOH + NH₄⁺</p> <p>OR</p> <p>CH₃CH₂CN + HCl + 2H₂O → CH₃CH₂COOH + NH₄Cl (2)</p> <p>If equation is incorrect then presence of H⁺ or acid in equation/or above arrow and water on LHS scores (1) Mark cq on formula of nitrile</p> <p>ALLOW one mark for the following equation without H⁺. CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₃</p> <p>ALLOW two marks for either of the following with H⁺ above the arrow CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₃ CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₄⁺</p> <p>ALLOW answers for alkaline hydrolysis followed by acidification CH₃CH₂CN + OH⁻ + H₂O → CH₃CH₂COO⁻ + NH₃ (1)</p> <p>Then CH₃CH₂COO⁻ + H⁺ → CH₃CH₂COOH (1)</p> <p>If propanamide, CH₃CH₂CONH₂ is given initially then ALLOW the two equation marks for the hydrolysis CH₃CH₂ CONH₂ + H⁺ + H₂O → CH₃CH₂COOH + NH₄⁺</p> <p>If no acid is used then only one mark CH₃CH₂ CONH₂ + H₂O → CH₃CH₂COOH + NH₃</p> | Hydroxynitriles | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--|----------|
| 19(b) | Reagent - Propanoyl chloride/ $\text{CH}_3\text{CH}_2\text{COCl}$ (1) Any two from: C-Cl bond is weaker (than C- O) (1) Cl^- /chloride (ion) is a better leaving group (1) Carbonyl carbon is more positive/more δ^+ /more attractive to nucleophiles (1) OR Reagent - Propanoic anhydride/ $(\text{CH}_3\text{CH}_2\text{CO})_2\text{O}$ (1) CH_3COO^- /propanoate (ion) is a better leaving group (1) Carbonyl carbon is more positive/more δ^+ /more attractive to nucleophiles (1) IGNORE references to eversible/equilibrium/ catalysts IGNORE bond polarity | Propyl chloride Just Cl is more electronegative | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|-----------------------------|------------|----------|
| 19(c)(i) | Radio waves/radio frequency | Just radio | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|--|----------|
| 19(c)(ii) | <p>Any two from:</p> <p>Protons/nuclei/they have a property called spin/ have a magnetic moment/ have a magnetic field/ are aligned with the external magnetic field (1)</p> <p>which flips/changes (1)</p> <p>align against the external magnetic field (when radiation is absorbed) (1)</p> | <p>starts to spin</p> <p>just dipole moment</p> <p>polarity flips</p> <p>any reference to electrons or molecules scores zero</p> | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|---|--------|----------|
| 19(c)(iii) | <p>Quartet (1)</p> <p>ALLOW quadruplet/indication of four (peaks)</p> <p>Value from 0.1 to 1.9 (ppm) inclusive (1)</p> <p>ACCEPT any range within the above range</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------------------|----------|
| 20(a) | (Greater yield) as fewer moles/molecules (of gas) on RHS OR 3 moles/molecules on left but only 1 on right (1) ALLOW arguments in terms of K_p remaining constant Disadvantage: Extra cost of (building) equipment (to withstand higher pressure)/ thicker pipes/compressor/maintaining equipment (1) OR Higher cost of energy needed for compression (1) IGNORE references to explosion | Just (higher) cost | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|----------|
| 20(b)(i) | (Reaction is exothermic) so the value of $\Delta S_{\text{surroundings}}$ becomes more positive/larger (at 100 °C) (1) Therefore ΔS_{total} becomes more positive/larger/less negative(at 100 °C) (1) Second mark consequential on first | | 2 |

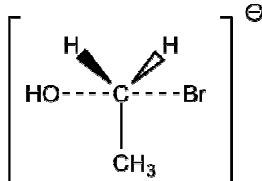
| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|--------|----------|
| 20(b)(ii) | (Higher temperature gives a) faster rate of reaction /more particles have $E \geq E_a$ (ALLOW more successful collisions (per second)) IGNORE references to yield | | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|--|--------|----------|
| 20(c) | Remove methanol/the product (as it is formed) (1) Recycle/reuse unreacted reactants (1) IGNORE references to catalyst and increasing amounts of reactants | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|-----------------------|----------|
| 21(a)(i) | $k = (1.54 \times 10^{-6}) \div (0.1 \times 0.15)$ (1) $(= 1.0267 \times 10^{-4})$ $= 1.03 \times 10^{-4}$ (1) must be to 3 SF $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$ (1) Unit mark is stand alone and units can be in any order Correct answer with units but no working (3) marks | 1.02×10^{-4} | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|--------|----------|
| 21(a)(ii) | If correct unrounded answer to (a) (i) stored in calculator then $4.1067 \times 10^{-8} = 4.1 \times 10^{-8} (\text{mol dm}^{-3} \text{s}^{-1})$ OR If 1.0267×10^{-4} used then $4.1068 \times 10^{-8} = 4.1 \times 10^{-8} (\text{mol dm}^{-3} \text{s}^{-1})$ OR If 1.03×10^{-4} used then $4.12 \times 10^{-8} = 4.1 \times 10^{-8} (\text{mol dm}^{-3} \text{s}^{-1})$ IGNORE sf except 1sf IGNORE units even if incorrect TE from (a)(i) | | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|----------|
| 21(b)(i) | $2^{(nd)}/\text{second}/\text{two}/(1 + 1) = 2$ (order) | | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|--------|----------|
| 21(b)(ii) |  <p>Structure (1) ALLOW structure without wedged bonds Dotted bonds must be shown and OH and Br must be on opposite sides with a C-C or C-H bond between them</p> <p>Charge (1) Charge mark can be awarded for a near miss with a single error in the structure (e.g. one hydrogen atom missing)</p> <p>ALLOW -ve charge shown as δ- on both OH and Br Brackets not essential</p> <p>ALLOW -ve charge to be anywhere on the structure IGNORE δ+ on carbon atom</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|----------|
| 21(c)(i) | 3.00×10^{-3} (1) IGNORE sf for 1/T | -5.60 | 2 |
| | -5.58 (1) IGNORE sf except 1sf | | |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|-----------------|----------|
| 21(c)(ii) | <p>Appropriate scale (1) Plotted points must cover at least half of the graph paper on each axis.</p> <p>Points plotted correctly and straight line drawn (1) through all points</p> <p>Gradient = -10230 ± 500 (1)</p> <p>Example $E_a = 10230 \times 8.31$ (1) allow TE from incorrect gradient</p> <p>$E_a = (+) 85.0 \text{ kJ}(\text{mol}^{-1}) / (+) 85\,000 \text{ J}(\text{mol}^{-1})$ (1) 3 sf</p> <p>E_a range from 80.9 to 89.2 kJ mol⁻¹</p> <p>ALLOW TE from incorrect gradient</p> <p>IGNORE SF except 1</p> | K ⁻¹ | 5 |

TOTAL FOR SECTION B = 49 MARKS

Section C

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|----------|
| 22(a)(i) | (+)186.2 (J mol ⁻¹ K ⁻¹) | | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|--|--------|----------|
| 22(a)(ii) | <p>(266.9 + 186.2) – 310.1 (1)</p> <p>= + 143 (J mol⁻¹ K⁻¹) (1)</p> <p>– 143 scores (1)</p> <p>Correct answer with sign and no working scores (2) marks</p> <p>ALLOW TE from (i)</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-------------------|--|--------|----------|
| 22(a)(iii) | <p>Yes, as reaction produces 2 molecules/moles from one/more molecules/moles (1)</p> <p>(and) all products are gases (1)</p> <p>IGNORE references to volumes</p> <p>More moles/molecules of gas produced scores (2)</p> <p>OR</p> <p>Yes, (as the reaction is endothermic) $\Delta S_{\text{surroundings}}$ is negative (1)</p> <p>Since the reaction takes place/goes (spontaneously) ΔS_{total} is positive and therefore ΔS_{system} is positive (1)</p> <p>ALLOW TE from (a)(ii) i.e. 'No, as....'</p> | | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|-----------|----------|
| 22(a)(iv) | $\Delta S_{\text{surr}} = -\Delta H/T$ (1) $= -71900/700$ $= -102.7 \text{ J K}^{-1} \text{ mol}^{-1} / -0.1027 \text{ kJ K}^{-1} \text{ mol}^{-1}$ (1) Correct answer and sign with no working scores (2) $-0.103 \text{ J K}^{-1} \text{ mol}^{-1}$ scores (1) Third mark So ΔS_{total} is positive (so reaction is feasible) (1) OR $\Delta S_{\text{total}} = +40.3 \text{ J K}^{-1} \text{ mol}^{-1}$ (so reaction is feasible) (1) ALLOW TE from (a)(ii) | 1 or 2 sf | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|----------|
| 22(a)(v) | $\Delta S_{\text{total}} = 0$ OR $\Delta S_{\text{surroundings}} = -143$ (1) $T = \Delta H \div \Delta S_{\text{surroundings}}$ OR $T = (-) 71900 \div (-) 143$ (1) $= 502.8 \text{ (K)}$ (1) IGNORE sf except 1sf Correct answer with no working scores (3) ALLOW 0.5028 (K) for (2) marks ALLOW -502.8 (K) for (2) marks ALLOW -0.5028 (K) for (1) mark ALLOW TE from (a)(ii) If the calculation is not based on $\Delta S_{\text{total}} = 0$ then a maximum of (2) marks can be awarded if done correctly | | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|--------|----------|
| 22(b) | <p>The catalyst is in a different state/phase to the reactants (1)</p> <p>IGNORE references to products</p> <p>Any two from</p> <p>It provides an alternative (reaction) route/mechanism/gases adsorbed on catalyst surface (1)</p> <p>Of lower activation energy/weakens bonds in reactants (1)</p> <p>Greater proportion of molecules have $E \geq E_a$ (1)</p> | | 3 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|------------------------------|----------|
| 23(a)(i) | $(K_a =) [H^+][C_6H_5COO^-]/[C_6H_5COOH]$ Penalise missing charges ALLOW $[H_3O^+]$ in place of $[H^+]$ IGNORE state symbols and units even if incorrect | $K_a = [H^+]^2/[C_6H_5COOH]$ | 1 |

| Question Number | Acceptable Answers | Reject | Mark |
|------------------|---|-----------------------|----------|
| 23(a)(ii) | $[H^+] = \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ (1) $pH = -\log \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ $= 3.4$ (1) Answer without working scores (2) marks 6.8 scores (1) IGNORE sf except 1 | answer if units given | 2 |

| Question Number | Acceptable Answers | Reject | Mark |
|-----------------|---|------------------------|----------|
| 23(b) | (pH) range (of indicator) 3.8 to 5.4 OR $pK_{in} = 4.7$ (1) Bubble bath is (initially yellow since) pH less than 3.8 / is 3.4 (1) Adding of water/dilution (of acid) causes pH to rise/ means $[H^+]$ decreases (1) Hence pH rises to ≥ 5.4 so blue/changes colour (1) If a(ii) $pH > 3.8$ and < 5.4 then loses second marking point but can score other marking points. If a(ii) $pH > 5.4$ then can score first and third marking points only | Water neutralizes acid | 4 |

TOTAL FOR SECTION C = 21 MARKS

TOTAL FOR PAPER = 90 MARKS

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