Diploma Programme
Programme du diplôme
Programa del Diploma

# Markscheme

## November 2016

## Chemistry

## Standard level

## Paper 2

13 pages

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 1. | a | i | «$K_c$ =» $\frac{[HOCH_2CH_2OH]}{[CO]^2 \times [H_2]^3}$ ✓ | | 1 |
| 1. | a | ii | *Position of equilibrium*: moves to right<br>***OR***<br>favours product ✓<br><br>$K_c$: no change<br>***OR***<br>is a constant at constant temperature ✓ | | 2 |
| 1. | a | iii | *Bonds broken*: 2C≡O + 3(H–H) / 2(1077 kJ mol$^{-1}$) + 3(436 kJ mol$^{-1}$) / 3462 «kJ» ✓<br><br>*Bonds formed*: 2(C–O) + 2(O–H) + 4(C–H) + (C–C) / 2(358 kJ mol$^{-1}$) + 2(463 kJ mol$^{-1}$) + 4(414 kJ mol$^{-1}$) + 346 kJ mol$^{-1}$ / 3644 «kJ» ✓<br><br>«Enthalpy change = bonds broken − bonds formed = 3462 kJ − 3644 kJ =» −182 «kJ» ✓ | *Award **[3]** for correct final answer.*<br>*Award **[2 max]** for «+»182 «kJ».* | 3 |
| 1. | a | iv | in (a)(iii) gas is formed and in (a)(iv) liquid is formed<br>***OR***<br>products are in different states<br>***OR***<br>conversion of gas to liquid is exothermic<br>***OR***<br>conversion of liquid to gas is endothermic<br>***OR***<br>enthalpy of vapourisation needs to be taken into account ✓ | *Accept product is «now» a liquid.*<br><br>*Accept answers referring to bond enthalpies being means/averages.* | 1 |

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*(Question 1 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 1. | b | | *Ethene*: −2 ✓<br><br>*Ethane-1,2-diol*: −1 ✓ | *Do **not** accept 2–, 1– respectively.* | **2** |
| 1. | c | | ethane-1,2-diol can hydrogen bond to other molecules «and ethene cannot»<br>***OR***<br>ethane-1,2-diol has «significantly» greater van der Waals forces ✓<br><br>hydrogen bonding is «significantly» stronger than other intermolecular forces ✓ | *Accept converse arguments.*<br>*Award **[0]** if answer implies covalent bonds are broken.* | **2** |
| 1. | d | | acidified «potassium» dichromate«(VI)» / $H^+$ ***AND*** $K_2Cr_2O_7$ / $H^+$ ***AND*** $Cr_2O_7^{2-}$<br>***OR***<br>«acidified potassium» manganate(VII) / «$H^+$» $KMnO_4$ / «$H^+$» $MnO_4^-$ ✓ | *Accept $H_2SO_4$ or $H_3PO_4$ for $H^+$.*<br><br>*Accept "permanganate" for "manganate(VII)".* | **1** |

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| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 2. | a | | *Weak acid*: partially dissociated/ionized **«**in solution/water**»**<br>***AND***<br>*Strong acid*: **«**assumed to be almost**»** completely/100 % dissociated/ionized **«**in solution/water**»** ✓ | *Accept answers relating to pH, conductivity, reactivity if solutions of equal concentrations stated.* | **1** |
| 2. | b | | **«**log scale**»** reduces a wide range of numbers to a small range<br>***OR***<br>simple/easy to use<br>***OR***<br>converts exponential expressions into linear scale/simple numbers ✓ | *Do **not** accept "easy for calculations".* | **1** |
| 2. | c | i | **«**$n(NaOH) = \left(\frac{14.0}{1000}\right) dm^3 \times 0.100\,mol\,dm^{-3}$ **=»** $1.40 \times 10^{-3}$ **«**mol**»** ✓ | | **1** |
| 2. | c | ii | **«**$\frac{1}{2} \times 1.40 \times 10^{-3}$ **=»** $7.00 \times 10^{-4}$ **«**mol**»** ✓ | | **1** |

*(continued)*

*(Question 2 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 2. | c | iii | ***ALTERNATIVE 1:***<br>«mass of pure hydrated ethanedioic acid in each titration = $7.00 \times 10^{-4}$ mol × 126.08 g $mol^{-1}$ =» 0.0883 / $8.83 \times 10^{-2}$ «g» ✓<br>mass of sample in each titration = « $\frac{25}{1000} \times 5.00\,g$ =» 0.125 «g» ✓<br>«% purity = $\frac{0.0883\,g}{0.125\,g} \times 100$ =» 70.6 «%» ✓<br><br>***ALTERNATIVE 2:***<br>«mol of pure hydrated ethanedioic acid in 1 $dm^3$ solution = $7.00 \times 10^{-4} \times \frac{1000}{25}$ =» $2.80 \times 10^{-2}$ «mol» ✓<br>«mass of pure hydrated ethanedioic acid in sample = $2.80 \times 10^{-2}$ mol × 126.08 g $mol^{-1}$ =» 3.53 «g» ✓<br>«% purity = $\frac{3.53\,g}{5.00\,g} \times 100$ =» 70.6 «%» ✓<br><br>***ALTERNATIVE 3:***<br>mol of hydrated ethanedioic acid (assuming sample to be pure) = $\frac{5.00\,g}{126.08\,g\,mol^{-1}} = 0.03966$ «mol» ✓<br>actual amount of hydrated ethanedioic acid =<br>«$7.00 \times 10^{-4} \times \frac{1000}{25}$ =» $2.80 \times 10^{-2}$ «mol» ✓<br>«% purity = $\frac{2.80 \times 10^{-2}}{0.03966} \times 100$ =» 70.6 «%» ✓ | *Award suitable part marks for alternative methods.*<br><br>*Award **[3]** for correct final answer.*<br><br>*Award **[2 max]** for 50.4 % if anhydrous ethanedioic acid assumed.* | **3** |

*(continued)*

*(Question 2 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **2.** | **d** | | electrons delocalized «across the O–C–O system»<br>***OR***<br>resonance occurs ✓<br><br>122 «pm» < C–O < 143 «pm» ✓ | *Accept delocalized π-bond(s).*<br><br>*Accept any answer in the range 123 «pm» to 142 «pm».*<br>*Accept "bond intermediate between single and double bond" or "bond order 1.5".* | **2** |

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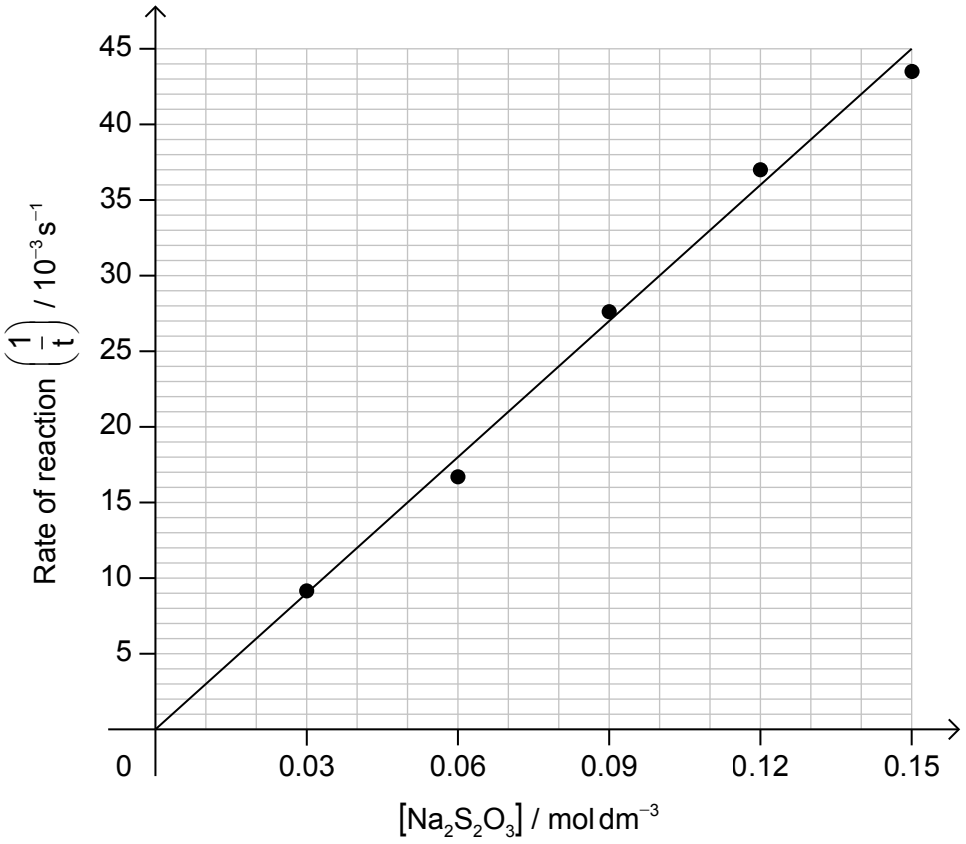
|---|---|---|---|---|---|
| **3.** | **a** | | $H_2O$ ***AND*** (l) ✓ | *Do **not** accept $H_2O$ (aq).* | **1** |
| | **b** | | $SO_2$ (g) is an irritant/causes breathing problems<br>***OR***<br>$SO_2$ (g) is poisonous/toxic ✓ | *Accept $SO_2$ (g) is acidic, but do not accept "causes acid rain".*<br>*Accept $SO_2$ (g) is harmful.*<br>*Accept $SO_2$ (g) has a foul/pungent smell.* | **1** |
| | **c** | | $n(HCl) = \text{«}\frac{10.0}{1000}\,dm^3 \times 2.00\,mol\,dm^{-3} =\text{»}\ 0.0200 / 2.00 \times 10^{-2}$ «mol»<br>***AND***<br>$n(Na_2S_2O_3) = \text{«}\frac{50}{1000}\,dm^3 \times 0.150\,mol \times dm^{-3} =\text{»}\ 0.00750 / 7.50 \times 10^{-3}$ «mol» ✓<br>0.0200 «mol» > 0.0150 «mol»<br>***OR***<br>$2.00 \times 10^{-2}$ «mol» > $2 \times 7.50 \times 10^{-3}$ «mol»<br>***OR***<br>$\frac{1}{2} \times 2.00 \times 10^{-2}$ «mol» > $7.50 \times 10^{-3}$ «mol» ✓ | *Accept answers based on volume of solutions required for complete reaction.*<br><br>*Award **[2]** for second marking point.*<br><br>*Do **not** award M2 unless factor of 2 (or half) is used.* | **2** |

*(continued)*

*(Question 3 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 3. | d | |  <br>five points plotted correctly ✓<br>best fit line drawn with ruler, going through the origin ✓ | | **2** |

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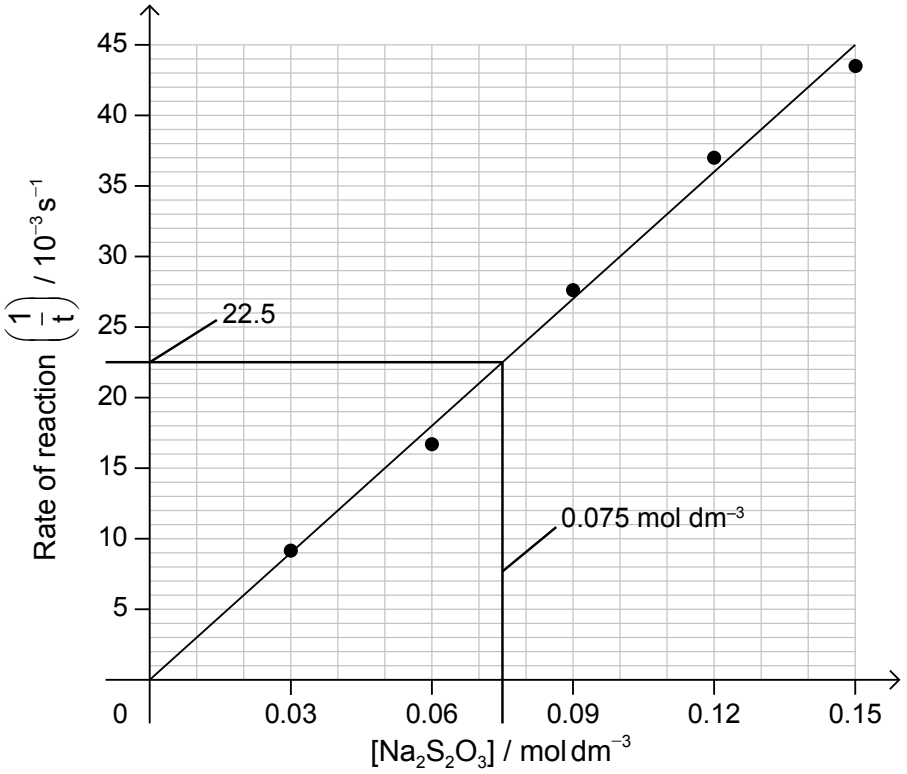
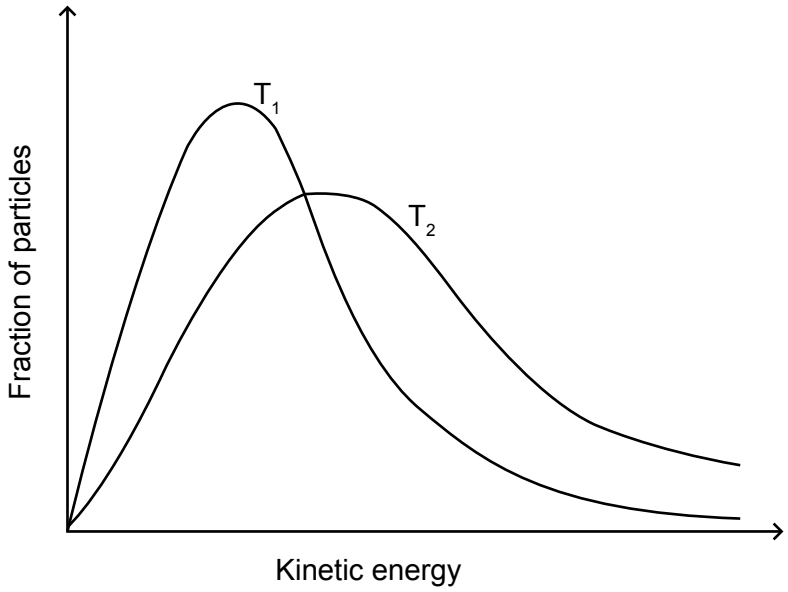
*(Question 3 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 3. | e | |  <br>$22.5 \times 10^{-3}$ «$s^{-1}$» ✓<br>«Time = $\frac{1}{22.5 \times 10^{-3}}$ =» 44.4 «s» ✓ | *Award **[2]** for correct final answer.*<br>*Accept value based on candidate's graph.*<br><br>*Award M2 as ECF from M1.*<br><br>*Award **[1 max]** for methods involving taking mean of appropriate pairs of $\frac{1}{t}$ values.*<br><br>*Award **[0]** for taking mean of pairs of time values.*<br><br>*Award **[2]** for answers between 42.4 and 46.4 **«s»**.* | **2** |

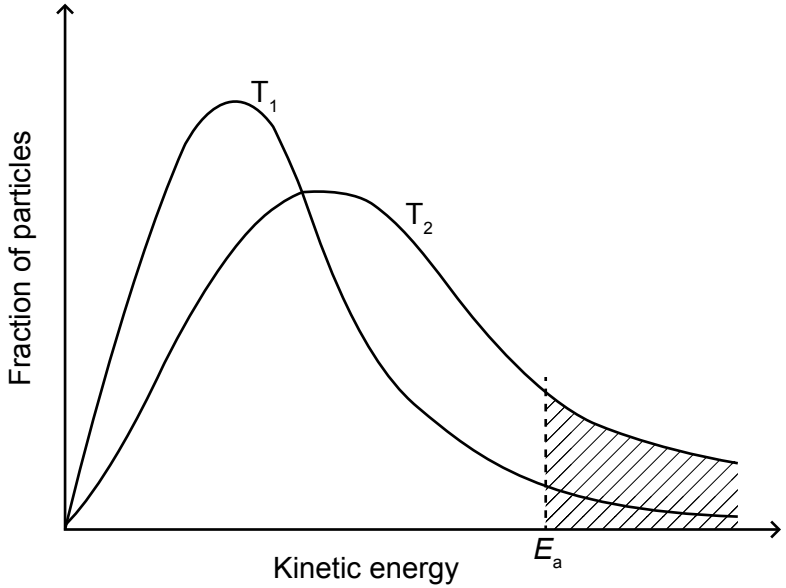
*(continued)*

*(Question 3 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 3. | f | i |  <br>correctly labelled axes ✓<br>peak of $T_2$ curve lower ***AND*** to the right of $T_1$ curve ✓ | *Accept "probability «density» / number of particles / N / fraction" on y-axis.*<br>*Accept "kinetic E/KE/$E_K$" but **not** just "Energy/E" on x-axis.* | **2** |

*(continued)*

*(Question 3 continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **3.** | **f** | **ii** | greater proportion of molecules have $E \geq E_a$ or $E > E_a$<br>***OR***<br>greater area under curve to the right of the $E_a$ ✓<br><br>greater frequency of collisions «between molecules»<br>***OR***<br>more collisions per unit time/second ✓<br><br>  <br> | *Accept more molecules have energy greater than $E_a$.*<br>*Do **not** accept just "particles have greater kinetic energy".*<br>*Accept "rate/chance/probability/likelihood/" instead of "frequency".*<br>*Accept suitably shaded/annotated diagram.*<br>*Do **not** accept just "more collisions".* | **2** |
| **3.** | **g** | | shorter reaction time so larger «%» error in timing/seeing when mark disappears ✓ | *Accept cooling of reaction mixture during course of reaction.* | **1** |

*(continued)*

| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| 4. | a | | $^{26}_{12}Mg$ ✓ | | 1 |
| 4. | b | | «$A_r$ =» $\frac{24 \times 78.60 + 25 \times 10.11 + 26 \times 11.29}{100}$ ✓<br>«= 24.3269 =» 24.33 ✓ | *Award **[2]** for correct final answer.*<br>*Do **not** accept data booklet value (24.31).* | 2 |
| 4. | c | | $MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(s)$<br>***OR***<br>$MgO(s) + H_2O(l) \rightarrow Mg^{2+}(aq) + 2OH^-(aq)$ ✓ | *Accept* ⇌. | 1 |
| 4. | d | | from basic to acidic ✓<br>through amphoteric ✓ | *Accept "alkali/alkaline" for "basic".*<br>*Accept "oxides of Na and Mg: basic **AND** oxide of Al: amphoteric" for M1.*<br>*Accept "oxides of non-metals/Si to Cl acidic" for M2.*<br>*Do **not** accept just "become more acidic".* | 2 |
| 4. | e | | $Mg_3N_2$ ✓ | *Accept $MgO_2$, $Mg(OH)_2$, $Mg(NOx)_2$, $MgCO_3$.* | 1 |
| 4. | f | | «3-D/giant» regularly repeating arrangement «of ions»<br>***OR***<br>lattice «of ions» ✓<br><br>electrostatic attraction between oppositely charged ions<br>***OR***<br>electrostatic attraction between $Mg^{2+}$ and $O^{2-}$ ions ✓ | *Accept "giant" for M1, unless "giant covalent" stated.*<br><br>*Do **not** accept "ionic" without description.* | 2 |
| 4. | g | | *Anode (positive electrode)*:<br>$2Cl^- \rightarrow Cl_2(g) + 2e^-$ ✓<br><br>*Cathode (negative electrode)*:<br>$Mg^{2+} + 2e^- \rightarrow Mg(l)$ ✓ | *Penalize missing/incorrect state symbols at $Cl_2$ and Mg once only.*<br>*Award **[1 max]** if equations are at wrong electrodes.*<br>*Accept Mg(g).* | 2 |

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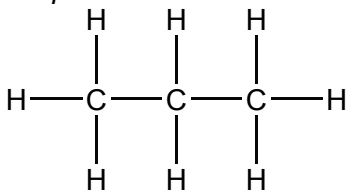
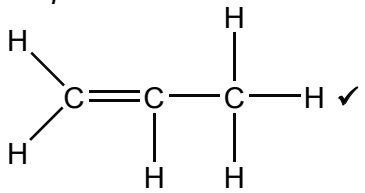
| Question | | | Answers | Notes | Total |
|---|---|---|---|---|---|
| **5.** | **a** | | *Propane*:<br>  <br>***AND***<br>*Propene*:<br>  ✓ | | **1** |
| **5.** | **b** | **i** | $C_3H_8 + Br_2 \rightarrow C_3H_7Br + HBr$ ✓<br><br>**«**sun**»**light/UV/$h\nu$<br>***OR***<br>high temperature ✓ | *Do **not** accept "reflux" for M2.* | **2** |
| **5.** | **b** | **ii** | $C_3H_6 + Br_2 \rightarrow C_3H_6Br_2$ ✓ | | **1** |
| **5.** | **b** | **iii** | *Propane*: **«**free radical**»** substitution / $S_R$<br>***AND***<br>*Propene*: **«**electrophilic**»** addition / $A_E$ ✓ | *Award mark even if incorrect type of substitution/ addition given.* | **1** |