

# Markscheme

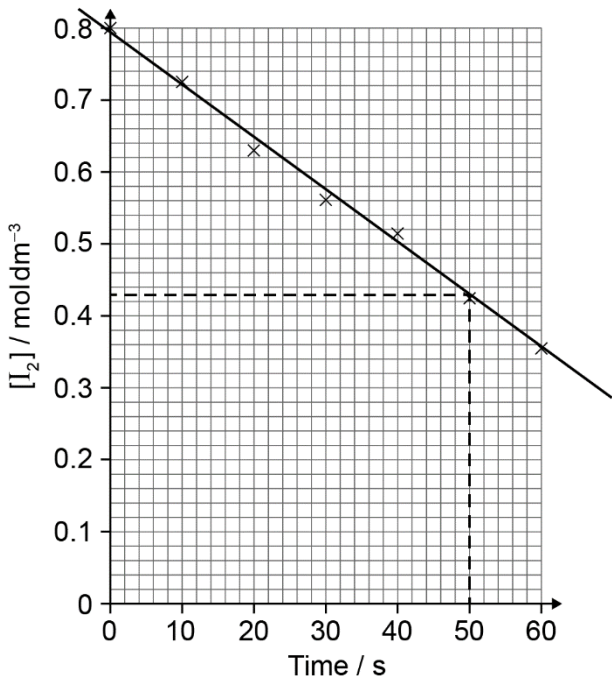
**May 2017**

**Chemistry**

**Standard level**

**Paper 2**

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Question			Answers	Notes	Total
1.	a	i	use a colorimeter/monitor the change in colour <b>OR</b> take samples <b>AND</b> quench <b>AND</b> titrate «with thiosulfate» ✓	Accept change in pH. Accept change in conductivity. Accept other suitable methods. Method must imply "change".	1
1.	a	ii	 <p>best fit line ✓</p> <p>relative rate of reaction = <math>\frac{-\Delta y}{\Delta x} = \frac{-(0.43 - 0.80)}{50} = 0.0074 / 7.4 \times 10^{-3}</math> ✓</p>	Best fit line required for M1.      M2 is independent of M1.  Accept range from 0.0070 to 0.0080.	2
1.	b		<p><i>Relationship:</i> rate of reaction is «directly» proportional to <math>[H^+]</math> <b>OR</b> rate of reaction <math>\propto [H^+]</math> ✓</p> <p><i>Explanation:</i> more frequent collisions/more collisions per unit of time «at greater concentration» ✓</p>	Accept "doubling the concentration doubles the rate". Do <b>not</b> accept "rate increases as concentration increases".  Do <b>not</b> accept collisions more likely.	2

Question			Answers	Notes	Total
2.	a		electrostatic attraction ✓ between «a lattice of» metal/positive ions/cations <b>AND</b> «a sea of» delocalized electrons ✓	Accept mobile electrons. Do <b>not</b> accept "metal atoms/nuclei".	2
2.	b		$\frac{(46 \times 7.98) + (47 \times 7.32) + (48 \times 73.99) + (49 \times 5.46) + (50 \times 5.25)}{100}$ ✓ = 47.93 ✓	Answer must have two decimal places with a value from 47.90 to 48.00. Award [2] for correct final answer. Award [0] for 47.87 (data booklet value).	2
2.	c		Protons: 22 <b>AND</b> Neutrons: 26 <b>AND</b> Electrons: 22 ✓		1
2.	d	i	1s <sup>2</sup> 2s <sup>2</sup> 2p <sup>6</sup> 3s <sup>2</sup> 3p <sup>6</sup> 3d <sup>2</sup> ✓		1
2.	d	ii	titanium atoms/ions distort the regular arrangement of atoms/ions <b>OR</b> titanium atoms/ions are a different size to aluminium «atoms/ions» ✓  prevent layers sliding over each other ✓	Accept diagram showing different sizes of atoms/ions.	2
2.	e	i	ionic <b>OR</b> «electrostatic» attraction between oppositely charged ions ✓		1
2.	e	ii	«simple» molecular structure <b>OR</b> weak«er» intermolecular bonds <b>OR</b> weak«er» bonds between molecules ✓	Accept specific examples of weak bonds such as London/dispersion and van der Waals. Do <b>not</b> accept "covalent".	1
2.	f	i	TiCl <sub>4</sub> (l) + 2H <sub>2</sub> O (l) → TiO <sub>2</sub> (s) + 4HCl (aq) correct products ✓ correct balancing ✓	Accept ionic equation. Award M2 if products are HCl and a compound of Ti and O.	2

continued...

(Question 2f continued)

Question			Answers	Notes	Total
2.	f	ii	HCl causes breathing/respiratory problems <b>OR</b> HCl is an irritant <b>OR</b> HCl is toxic <b>OR</b> HCl has acidic vapour <b>OR</b> HCl is corrosive ✓	Accept "TiO <sub>2</sub> causes breathing problems/is an irritant". Accept "harmful" for both HCl and TiO <sub>2</sub> . Accept "smoke is asphyxiant".	1

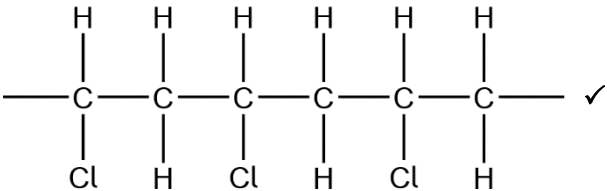
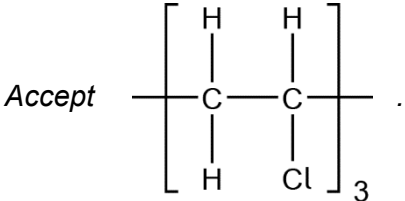
Question			Answers	Notes	Total
3.	a		V <sub>2</sub> O <sub>5</sub> : +5 ✓ VO <sup>2+</sup> : +4 ✓	Do <b>not</b> penalize incorrect notation twice.	2
3.	b		VO <sup>2+</sup> (aq) + V <sup>2+</sup> (aq) + 2H <sup>+</sup> (aq) → 2V <sup>3+</sup> (aq) + H <sub>2</sub> O (l) ✓	Accept equilibrium sign.	1

Question		Answers	Notes	Total
4.	a	107° ✓	Accept 100° to <109.5°. Literature value = 105.8°	1
4.	b	removes/reacts with OH <sup>-</sup> ✓ moves to the right/products «to replace OH <sup>-</sup> ions» ✓	Accept ionic equation for M1.	2
4.	c	N <sub>2</sub> H <sub>4</sub> (aq) + H <sub>2</sub> O (l) ⇌ N <sub>2</sub> H <sub>5</sub> <sup>+</sup> (aq) + OH <sup>-</sup> (aq) ✓	Accept N <sub>2</sub> H <sub>4</sub> (aq) + 2H <sub>2</sub> O (l) ⇌ N <sub>2</sub> H <sub>6</sub> <sup>2+</sup> (aq) + 2OH <sup>-</sup> (aq). Equilibrium sign must be present.	1
4.	d	bubbles <b>OR</b> gas <b>OR</b> magnesium disappears ✓  2NH <sub>4</sub> <sup>+</sup> (aq) + Mg (s) → Mg <sup>2+</sup> (aq) + 2NH <sub>3</sub> (aq) + H <sub>2</sub> (g) ✓	Do <b>not</b> accept "hydrogen" without reference to observed changes. Accept "smell of ammonia".  Accept 2H <sup>+</sup> (aq) + Mg (s) → Mg <sup>2+</sup> (aq) + H <sub>2</sub> (g) Equation must be ionic.	2
4.	e	no oxygen required ✓		1
4.	f	bonds broken: E(N–N) + 4E(N–H) <b>OR</b> 158 «kJ mol <sup>-1</sup> » + 4 × 391 «kJ mol <sup>-1</sup> » / 1722 «kJ» ✓  bonds formed: E(N≡N) + 2E(H–H) <b>OR</b> 945 «kJ mol <sup>-1</sup> » + 2 × 436 «kJ mol <sup>-1</sup> » / 1817 «kJ» ✓  «ΔH = bonds broken – bonds formed = 1722 – 1817 ⇒ -95 «kJ» ✓	Award [3] for correct final answer. Award [2 max] for +95 «kJ».	3

Question			Answers	Notes	Total
4.	g		$\text{N}_2\text{H}_4(\text{g}) \xrightarrow{-95 \text{ kJ mol}^{-1}} \text{N}_2(\text{g}) + 2\text{H}_2(\text{g})$ <p><b>OR</b></p> $\Delta H_{\text{vap}} = -50.6 \text{ kJ mol}^{-1} - (-95 \text{ kJ mol}^{-1}) \checkmark$ $\ll \Delta H_{\text{vap}} = \gg +44 \ll \text{kJ mol}^{-1} \gg \checkmark$	<p><i>Award [2] for correct final answer.</i>  <i>Award [1 max] for <math>-44 \ll \text{kJ mol}^{-1} \gg</math>.</i></p> <p><i>Award [2] for:</i>  <math>\Delta H_{\text{vap}} = -50.6 \text{ kJ mol}^{-1} - (-95 \text{ kJ mol}^{-1})</math>  <math>+ = 34 \ll \text{kJ mol}^{-1} \gg</math>.  <i>Award [1 max] for <math>-34 \ll \text{kJ mol}^{-1} \gg</math>.</i></p>	2
4.	h	i	<p>total mass of oxygen <math>\ll = 8.0 \times 10^{-3} \text{ g dm}^{-3} \times 1000 \text{ dm}^3 \gg = 8.0 \ll \text{g} \gg \checkmark</math></p> $n(\text{O}_2) \ll = \frac{8.0 \text{ g}}{32.00 \text{ g mol}^{-1}} = \gg 0.25 \ll \text{mol} \gg$ <p><b>OR</b></p> $n(\text{N}_2\text{H}_4) = n(\text{O}_2) \checkmark$ <p><math>\ll \text{mass of hydrazine} = 0.25 \text{ mol} \times 32.06 \text{ g mol}^{-1} = \gg 8.0 \ll \text{g} \gg \checkmark</math></p>	<p><i>Award [3] for correct final answer.</i></p>	3
4.	h	ii	$\ll n(\text{N}_2\text{H}_4) = n(\text{O}_2) = \frac{8.0 \text{ g}}{32.00 \text{ g mol}^{-1}} = \gg 0.25 \ll \text{mol} \gg$ <p><math>\ll \text{volume of nitrogen} = 0.25 \text{ mol} \times 24.8 \text{ dm}^3 \text{ mol}^{-1} \gg = 6.2 \ll \text{dm}^3 \gg \checkmark</math></p>	<p><i>Award [1] for correct final answer.</i></p>	1

Question			Answers	Notes	Total
5.	a		substitution <b>AND</b> «free-»radical <b>OR</b> substitution <b>AND</b> chain ✓	Award [1] for “«free-»radical substitution” or “S <sub>R</sub> ” written anywhere in the answer.	1
5.	b		Two propagation steps: C <sub>2</sub> H <sub>6</sub> + •Cl → C <sub>2</sub> H <sub>5</sub> • + HCl ✓ C <sub>2</sub> H <sub>5</sub> • + Cl <sub>2</sub> → C <sub>2</sub> H <sub>5</sub> Cl + •Cl ✓  One termination step: C <sub>2</sub> H <sub>5</sub> • + C <sub>2</sub> H <sub>5</sub> • → C <sub>4</sub> H <sub>10</sub> <b>OR</b> C <sub>2</sub> H <sub>5</sub> • + •Cl → C <sub>2</sub> H <sub>5</sub> Cl <b>OR</b> •Cl + •Cl → Cl <sub>2</sub> ✓	Accept radical without • if consistent throughout.  Allow ECF from incorrect radicals produced in propagation step for M3.	3
5.	c	i	C = $\frac{24.27}{12.01} = 2.021$ <b>AND</b> H = $\frac{4.08}{1.01} = 4.04$ <b>AND</b> Cl = $\frac{71.65}{35.45} = 2.021$ ✓ «hence» CH <sub>2</sub> Cl ✓	Accept $\frac{24.27}{12.01} : \frac{4.08}{1.01} : \frac{71.65}{35.45}$ . Do <b>not</b> accept C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> . Award [2] for correct final answer.	2
5.	c	ii	molecular ion peak(s) «about» m/z 100 <b>AND</b> «so» C <sub>2</sub> H <sub>4</sub> Cl <sub>2</sub> «isotopes of Cl» ✓ two signals «in <sup>1</sup> H NMR spectrum» <b>AND</b> «so» CH <sub>3</sub> CHCl <sub>2</sub> <b>OR</b> «signals in» 3:1 ratio «in <sup>1</sup> H NMR spectrum» <b>AND</b> «so» CH <sub>3</sub> CHCl <sub>2</sub> <b>OR</b> one doublet and one quartet «in <sup>1</sup> H NMR spectrum» <b>AND</b> «so» CH <sub>3</sub> CHCl <sub>2</sub> ✓  1,1-dichloroethane ✓	Accept “peaks” for “signals”.  Allow ECF for a correct name for M3 if an incorrect chlorohydrocarbon is identified	3



Question		Answers	Notes	Total
5.	d		<p><i>Continuation bonds must be shown. Ignore square brackets and "n".</i></p> <p>Accept </p> <p><i>Accept other versions of the polymer, such as head to head and head to tail. Accept condensed structure provided all C to C bonds are shown (as single).</i></p>	1
6.	a	<p>Any two of: planar «X-ray» ✓</p> <p>C to C bond lengths all equal <b>OR</b> C to C bonds intermediate in length between C–C and C=C ✓</p> <p>all C–C–C bond angles equal ✓</p>	<p><i>Accept all C to C bonds have same bond strength/bond energy.</i></p>	2 max
6.	b	<p><i>benzene</i>: «electrophilic» substitution/S<sub>E</sub> <b>AND</b> <i>cyclohexene</i>: «electrophilic» addition/A<sub>E</sub> ✓</p>	<p><i>Accept correct equations.</i></p>	1