Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2018

Chemistry

Standard level

Paper 2

11 pages

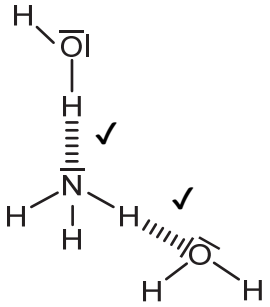
<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>1.</td><td>a</td><td>i</td><td>molar mass of urea «$= 4 \times 1.01 + 2 \times 14.01 + 12.01 + 16.00$» $= 60.07$ «g mol^{-1}» ✓

«% nitrogen $= \frac{2 \times 14.01}{60.07} \times 100 =$» 46.65 «%» ✓</td><td>Award [2] for correct final answer.

Award [1 max] for final answer not to two decimal places.</td><td>2</td></tr>
<tr><td>1.</td><td>a</td><td>ii</td><td>«cost» increases AND lower N % «means higher cost of transportation per unit of nitrogen»
OR
«cost» increases AND inefficient/too much/about half mass not nitrogen ✓</td><td>Accept other reasonable explanations.

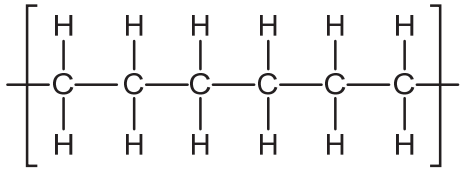
Do not accept answers referring to safety/explosions.</td><td>1</td></tr>
<tr><td>1.</td><td>b</td><td></td><td><table><tr><th></th><th>Electron geometry</th><th>Molecular geometry</th></tr><tr><td>Nitrogen</td><td>tetrahedral ✓</td><td>trigonal pyramidal ✓</td></tr><tr><td>Carbon</td><td>trigonal planar ✓</td><td>trigonal planar</td></tr></table></td><td>Note: Urea’s structure is more complex than that predicted from VSEPR theory.</td><td>3</td></tr>
<tr><td>1.</td><td>c</td><td></td><td>n(KNCO) «$= 0.0500\ \text{dm}^3 \times 0.100\ \text{mol dm}^{-3}$» $= 5.00 \times 10^{-3}$ «mol» ✓

«mass of urea $= 5.00 \times 10^{-3}\ \text{mol} \times 60.07\ \text{g mol}^{-1}$» $= 0.300$ «g» ✓</td><td>Award [2] for correct final answer.</td><td>2</td></tr>
<tr><td>1.</td><td>d</td><td></td><td>«K_c» decreases AND reaction is exothermic
OR
«K_c» decreases AND ΔH is negative
OR
«K_c» decreases AND reverse/endothermic reaction is favoured ✓</td><td></td><td>1</td></tr>
</table>

Question			Answers	Notes	Total
1.	e	i	*Any one of:* urea has greater molar mass ✓ urea has greater electron density/greater London/dispersion ✓ urea has more hydrogen bonding ✓ urea is more polar/has greater dipole moment ✓	*Accept "urea has larger size/greater van der Waals forces".* *Do **not** accept "urea has greater intermolecular forces/IMF".*	**1**
1.	e	ii	 ✓ ✓	*Award **[1]** for each correct interaction.* *If lone pairs are shown on N or O, then the lone pair on N or one of the lone pairs on O **MUST** be involved in the H-bond.* *Penalize solid line to represent H-bonding only once.*	**2**
1.	f		$2(H_2N)_2CO\,(s) + 3O_2\,(g) \rightarrow 4H_2O\,(l) + 2CO_2\,(g) + 2N_2\,(g)$ correct coefficients on LHS ✓ correct coefficients on RHS ✓	*Accept $(H_2N)_2CO\,(s) + \frac{3}{2} O_2\,(g) \rightarrow 2H_2O\,(l) + CO_2\,(g) + N_2\,(g)$.* *Accept any correct ratio.*	**2**

Question			Answers	Notes	Total
1.	**g**		*60:* $CON_2H_4^+$ ✓ *44:* $CONH_2^+$ ✓	*Accept "molecular ion".*	**2**
1.	**h**		*3450 cm^{-1}:* N–H ✓ *1700 cm^{-1}:* C=O ✓	*Do **not** accept "O–H" for 3450 cm^{-1}.*	**2**
1.	**i**		1 ✓		**1**

Question			Answers	Notes	Total
2.	a		electrostatic attraction ***AND*** oppositely charged ions ✓		1
2.	b		$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$ ***OR*** [Ar] ✓		1
2.	c		«promoted» electrons fall back to lower energy level ✓ energy difference between levels is different ✓	*Accept "Na and Ca have different nuclear charge" for M2.*	2
2.	d	i	*Any two of:* stronger metallic bonding ✓ smaller ionic/atomic radius ✓ two electrons per atom are delocalized ***OR*** greater ionic charge ✓ greater atomic mass ✓	*Do **not** accept just "heavier" or "more massive" without reference to atomic mass.*	2
2.	d	ii	delocalized/mobile electrons «free to move» ✓		1
2.	e		pH > 7 ✓	*Accept any specific pH value or range of values above 7 and below 14.*	1

Question			Answers	Notes	Total
3.	a	i	nickel/Ni «catalyst» ✓ high pressure ***OR*** heat ✓	*Accept these other catalysts: Pt, Pd, Ir, Rh, Co, Ti.* *Accept "high temperature" or a stated temperature such as "150 °C".*	**2**
3.	a	ii	 ✓	*Ignore square brackets and "n".* *Connecting line at end of carbons must be shown.*	**1**
3.	b	i	$\Delta H^{\ominus}$ = bonds broken − bonds formed ✓ «$\Delta H^{\ominus}$ = 3(C≡C) − 6(C⁼⁼C)$_{benzene}$ / 3 × 839 − 6 × 507 / 2517 − 3042 =» −525 «kJ» ✓	*Award **[2]** for correct final answer.* *Award **[1 max]** for +525 «kJ»* *Award **[1 max]** for:* *«$\Delta H^{\ominus}$ = 3(C≡C) − 3(C−C) − 3(C=C) / 3 × 839 − 3 × 346 − 3 × 614 / 2517 − 2880 =» −363 «kJ».*	**2**
3.	b	ii	$\Delta H^{\ominus} = \Sigma \Delta H_f$ (products) − $\Sigma \Delta H_f$ (reactants) ✓ «$\Delta H^{\ominus}$ = 49 kJ − 3 × 228 kJ =» −635 «kJ» ✓	*Award **[2]** for correct final answer.* *Award **[1 max]** for "+635 «kJ»".*	**2**

(continued…)

(Question 3b continued)

Question			Answers	Notes	Total
3.	**b**	**iii**	ΔH_f values are specific to the compound ***OR*** bond enthalpy values are averages **«**from many different compounds**»** ✓ condensation from gas to liquid is exothermic ✓	*Accept "benzene is in two different states **«**one liquid the other gas**»**" for M2.*	**2**
3.	**c**		equal C–C bond **«**lengths/strengths**»** ***OR*** regular hexagon ***OR*** **«**all**»** C–C have**»** bond order of 1.5 ***OR*** **«**all**»** C–C intermediate between single and double bonds ✓	*Accept "all C–C–C bond angles are equal".*	**1**
3.	**d**		electrophilic substitution ***OR*** S_E ✓		**1**

Question			Answers	Notes	Total
4.	a		*Any two of:* loss of mass **«**of reaction mixture/CO_2**»** ✓ **«**increase in**»** volume of gas produced ✓ change of conductivity ✓ change of pH ✓ change in temperature ✓	*Do **not** accept "disappearance of calcium carbonate".* *Do **not** accept "gas bubbles".* *Do **not** accept "colour change" or "indicator".*	**2**
4.	b	i	reaction is fast at high concentration ***AND*** may be difficult to measure accurately ***OR*** so many bubbles of CO_2 produced that inhibit contact of HCl (aq) with $CaCO_3$ (s) ***OR*** insufficient change in conductivity/pH at high concentrations ***OR*** calcium carbonate has been used up/is limiting reagent/there is not enough calcium carbonate **«**to react with the high concentration of HCl**»** ***OR*** HCl is in excess ***OR*** so many bubbles of CO_2 produced that inhibit contact of HCl (aq) with $CaCO_3$ (s) ✓		**1**
4.	b	ii	**«**directly**»** proportional ✓	*Accept "first order" or "linear".* *Do **not** accept "rate increases as concentration increases" or "positive correlation".*	**1**

Question			Answers	Notes	Total
5.	**a**		slower rate with ethanoic acid ***OR*** smaller temperature rise with ethanoic acid ✓ $[H^+]$ lower ***OR*** ethanoic acid is partially dissociated ***OR*** ethanoic acid is weak ✓	*Accept experimental observations such as "slower bubbling" or "feels less warm".*	**2**
5.	**b**		*Any one of:* corrosion of materials/metals/carbonate materials ✓ destruction of plant/aquatic life ✓ **«**indirect**»** effect on human health ✓	*Accept "lowering pH of oceans/lakes/waterways".*	**1**

Question			Answers	Notes	Total
6.	a		salt bridge ✓ movement of ions ***OR*** balance charge ✓	*Do **not** accept "to complete circuit" unless ion movement is mentioned for M2.*	**2**
6.	b		*Positive electrode (cathode):* $Ag^{+}(aq) + e^{-} \rightarrow Ag(s)$ ✓ *Negative electrode (anode):* $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^{-}$ ✓	*Award **[1 max]** if correct equations given at wrong electrodes.*	**2**
6.	c		in external wire from left to right ✓		**1**