

**GCE**  
**AS and A Level**

# **Chemistry**

**AS exams 2009 onwards**  
**A2 exams 2010 onwards**

## **Unit 5:** **Specimen mark scheme**

**Version 1.1**





**General Certificate of Education**

**Chemistry 2420**

**CHEM5 Energetics, Redox and  
Inorganic Chemistry**

**Mark Scheme**

*Specimen Paper*

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. The specimen assessment materials are provided to give centres a reasonable idea of the general shape and character of the planned question papers and mark schemes in advance of the first operational exams.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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**Question 1**

- |     |       |  |   |            |
|-----|-------|--|---|------------|
| (a) | (i)   | Oxide 1  | B   | (1)        |
|     |       | Oxide 2  | E   | (1)        |
|     |       | Explanation  | Low melting point or weak van der Waals' forces between molecules | (1)        |
|     | (ii)  | Chemical test  | Add water or flame test<br>Test pH or flame colour                | (1)<br>(1) |
|     |       | Observation  | pH = 13/14 or colour yellow                                       | (1)        |
| (b) | (i)   | Equation   | $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}$                | (1)        |
|     | (ii)  | Product  | $\text{CaSO}_3$   | (1)        |
|     | (iii) | Disposal of large quantities of $\text{CaSO}_3$ (allow $\text{CaSO}_4$ ) |   | (1)        |
|     |       | Produces $\text{CO}_2$ or uses up $\text{CaCO}_3$                        |   | (1)        |

**Question 2**

- |     |       |   |            |
|-----|-------|---|------------|
| (a) | (i)   | $1s^2 2s^2 2p^6 3s^2 3p^6$  | (1)        |
|     | (ii)  | The negative $\text{S}^-$ ion<br>repels the added electron                  | (1)<br>(1) |
|     | (iii) | Step B is the atomisation enthalpy of sulfur                                | (1)        |
|     |       | Step D is the second ionisation enthalpy of calcium                         | (1)        |
|     | (iv)  | Electrons nearer to the nucleus   | (1)        |
|     |       | Electrons removed from a positive species or more strongly attracted        | (1)        |
|     | (v)   | $+178 + 279 + 590 + 1145 - 200 + 539 + G + 482 = 0$                         | (1)        |
|     |       | $G + 3013 = 0$ hence $G = -3013$  | (1)        |
| (b) |       | The model used assumes the ions are spherical and in a lattice              | (1)        |
|     |       | The calculated value is smaller than the cycle value or stronger attraction | (1)        |
|     |       | Indicating some covalent character or ions are polarised                    | (1)        |

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- (c) (i) For a reaction to occur  $\Delta G < 0$  (1)  
 $\Delta S$  is positive and large as a gas is evolved (1)  
 $T\Delta S$  is larger than  $\Delta H$  and  $\Delta G$  is negative (1)
- (ii)  $\Delta S$  is negative (1)  
Four moles gaseous reactant forming or more moles of gaseous product (1)  
At high temperature  $T\Delta S$  is larger than  $\Delta H$  and  $\Delta G$  is positive (1)

**Question 3**

- (a) (i) HgO (1)  
(ii)  $\text{Hg}^{2+} + 2\text{e}^- \rightarrow \text{Hg}$  (1)  
(iii)  $2\text{H}_2\text{O} + \text{SO}_2 \rightarrow \text{H}_2\text{SO}_4 + 2\text{e}^-$  etc (1)  
(iv)  $\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-$  (1)
- (b) (i) Vanadium species:  $\text{VO}_2^+$  (1)  
Oxidation state: 5 (1)  
Half-equation:  $\text{V}^{2+} + 2\text{H}_2\text{O} \rightarrow \text{VO}_2^+ + 4\text{H}^+ + 3\text{e}^-$  (1)
- (ii) Cell e.m.f 0.06 V (1)  
(1)  
Change in e.m.f, Increases (1)  
More  $\text{Fe}^{3+}$  ions to accept electrons (1)  
 $\text{Fe}^{3+}/\text{Fe}^{2+}$  electrode becomes more positive
- (c) (i)  $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$  (1)  
 $4\text{e}^- + \text{O}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{OH}^-$  (1)  
Overall equation  $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
- (d) (ii) Unchanged (1)
- (e) Economic disadvantage; Use of  $\text{CH}_4$  or cost of producing or high temp (1)  
Environmental disadvantage; Makes  $\text{CO}_2$  (1)
- (e) Cost of manufacture of solar cells (1)
-

**Question 4**

- |     |             |  |     |
|-----|-------------|--|-----|
| (a) | Species     | $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$                                       | (1) |
|     | Precipitate | $\text{Co}(\text{H}_2\text{O})_4(\text{OH})_2$                                 | (1) |
| (b) |             | $[\text{Co}(\text{NH}_3)_6]^{2+}$  | (1) |
| (c) | Reaction    | Oxidation  | (1) |
|     | Reactant    | Oxygen in the air  | (1) |
| (d) | R           | Iodine   | (1) |
|     | Explanation | $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ oxidises $\text{I}^-$ to $\text{I}_2$ | (1) |

**Question 5**

- (a)  $\text{Fe} + \text{H}_2\text{SO}_4 \rightarrow \text{FeSO}_4 + \text{H}_2$  (1)
- (b)  $\text{MnO}_4^- + 8\text{H}^+ + 5\text{Fe}^{2+} \rightarrow \text{Mn}^{2+} + 4\text{H}_2\text{O} + 5\text{Fe}^{3+}$  (1)
- (c) Moles  $\text{MnO}_4^-$  in  $19.6 \text{ cm}^3$   
 $= 19.6 \times 0.022 \times 10^{-3} = 4.312 \times 10^{-4}$  (1)
- Moles  $\text{Fe}^{2+}$  in  $25 \text{ cm}^3$   
 $= 5 \times 4.312 \times 10^{-4} = 2.156 \times 10^{-3}$  (1)
- Moles  $\text{Fe}^{2+}$  in  $250 \text{ cm}^3$   
 $= 10 \times 2.156 \times 10^{-3} = 2.156 \times 10^{-2}$  (1)
- Mass  $\text{Fe}^{2+} = \text{moles} \times A_r$   
 $A_r = 2.156 \times 10^{-2} \times 55.8 = 1.203\text{g}$  (1)
- Percentage by mass of carbon  
 $= (1.270 - 1.203) \times 100/1.270$   
 $= 5.28\%$  (1)
- (d) Repeat the titration and take an average of the concordant results (1)
- (e) Analyse several samples from different parts of the molten iron (1)

**Question 6**

- (a) Equation:  
e.g.  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{Cl}^- \rightarrow [\text{CuCl}_4]^{2-} + 6\text{H}_2\text{O}$
- Species (1)  
Balance (1)
- Colours:  
e.g.  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  blue (1)  
e.g.  $[\text{CuCl}_4]^{2-}$  yellow/green (1)
- (b) (i)  $\Delta E$  :- The energy absorbed (1)  
h:- Planck's constant (1)
- (ii) Factor 1 Change of ligand (1)  
Factor 2 Change in oxidation state (1)  
Factor 3 Change in co-ordination number (1)

**Question 7**

- (a) Equation  $1/2\text{N}_2 + 3/2\text{H}_2 \rightleftharpoons \text{NH}_3$  (1)
- $\Delta H_f = [(945 \times 0.5) + (426 \times 1.5)] - (391 \times 3)$  (1)  
 $= -46.5 \text{ kJ mol}^{-1}$  (1)

Mark Range	Descriptor an answer will be expected to meet most of the criteria in the level descriptor
4-5	<ul style="list-style-type: none"> <li>- claims supported by an appropriate range of evidence</li> <li>- good use of information or ideas about chemistry, going beyond those given in the question</li> <li>- argument well structured with minimal repetition or irrelevant points</li> <li>- accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling</li> </ul>
2-3	<ul style="list-style-type: none"> <li>- claims partially supported by evidence</li> <li>- good use of information or ideas about chemistry given in the question but limited beyond this</li> <li>- the argument shows some attempt at structure</li> <li>- the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling</li> </ul>
0-1	- valid points but not clearly linked to an argument structure

	<ul style="list-style-type: none"> <li>- limited use of information or ideas about chemistry</li> <li>- unstructured</li> <li>- errors in spelling, punctuation and grammar or lack of fluency</li> </ul>		
(b)	The higher the temperature the faster the reaction	QWC	(1)
	but, since the reaction is exothermic		(1)
	the equilibrium yield is lower	QWC	(1)
	The higher the pressure the greater the equilibrium yield	QWC	(1)
	because there is a reduction in the number of moles of gas in the reaction		(1)
	but higher pressure is expensive to produce or plant is more expensive to build	QWC	(1)
	A better catalyst would lessen the time to reach equilibrium		(1)
	and allow more ammonia to be produced in a given time	QWC	(1)

**Question 8**

- (a)  $\text{FeCl}_3$  accepts electron pairs from water (1)
- Hence acts as a Lewis acid (1)
- $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$  donates protons (1)
- Hence acts as a Bronsted-Lowry acid (1)
- (b) The  $\text{Fe}^{2+}$  ion has a smaller charge to size ratio (1)
- Hence less polarising than  $\text{Fe}^{3+}$  or less weakening effect on O-H bonds (1)
- (c) (i)  $\text{V}_2\text{O}_5 + \text{SO}_2 \rightleftharpoons \text{V}_2\text{O}_4 + \text{SO}_3$  (1)
- $\text{V}_2\text{O}_4 + \text{O}_2 \rightleftharpoons \text{V}_2\text{O}_5$  (1)



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(ii)	Both ions are negative or ions repel		(1)
	$2\text{Fe}^{2+} + \text{S}_2\text{O}_8^{2-} \not\rightarrow 2\text{Fe}^{3+} + 2\text{SO}_4^{2-}$	Species	(1)
		Balanced	(1)
	$2\text{Fe}^{3+} + 2\text{I}^- \not\rightarrow 2\text{Fe}^{2+} + \text{I}_2$	Species	(1)
		Balanced	(1)

**Question 9**

- A chlorine atom has more protons in its nucleus than has a sodium atom (1)
- Both have three shells of electrons (1)
- Electrons more strongly attracted by chlorine nucleus so size smaller than Na (1)
- An electron shell is lost when a sodium ion is formed from a sodium atom (1)
- Inner electrons more strongly attracted so ion smaller than atom (1)
- An electron is added to the outer shell when a chloride ion is formed (1)
- Greater repulsion between shells so size of chloride ion greater than Cl atom (1)

**MAX 6**  
**QWC**