GCE
AS and A Level

Chemistry

AS exams 2009 onwards
A2 exams 2010 onwards

Unit 5:
Specimen mark scheme
Version 1.1

AQA

ASSESSMENT and

QUALIFICATIONS

ALLIANCE

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.

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	(1)
			Test pH or flame colour	(1)
		Observation	pH = 13/14 or colour yellow	(1)
(b)	(i)	Equation	$CaCO_3 \rightarrow CaO + CO$	(1)
	(ii)	Product	$CaSO_3$	(1)
	(iii)	Disposal of large quantities of $CaSO_3$ (allow $CaSO_4$)		(1)
		Produces CO_2 or uses up $CaCO_3$		(1)

Question 2

(a)	(i)	$1s^2\, 2s^2\, 2p^6\, 3s^2\, 3p^6$	(1)
	(ii)	The negative S^- ion	(1)
		repels the added electron	(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)

(c) (i) For a reaction to occur $\Delta G < 0$ (1)

ΔS is positive and large as a gas is evolved   (1)

$T\Delta S$ is larger than ΔH and ΔG is negative   (1)

(ii) ΔS is negative   (1)

Four moles gaseous reactant forming or more moles of gaseous product   (1)

At high temperature $T\Delta S$ is larger than ΔH and ΔG is positive   (1)

Question 3

(a) (i) HgO   (1)

(ii) $Hg^{2+} + 2e^- \rightarrow Hg$ (1)

(iii) $2H_2O + SO_2 \rightarrow H_2SO_4 + 2e^-$ etc   (1)

(iv) $Cl_2 + 2e^- \rightarrow 2Cl^-$ (1)

(b) (i) Vanadium species: VO_2^+ (1)

Oxidation state: 5   (1)

Half-equation: $V^{2+} + 2H_2O \rightarrow VO_2^+ + 4H^+ + 3e^-$ (1)

(ii) Cell e.m.f 0.06 V   (1)
                                                                                    (1)
Change in e.m.f, Increases   (1)
More Fe^{3+} ions to accept electrons   (1)
Fe^{3+}/Fe^{2+} electrode becomes more positive

(c) (i) $2H_2 \rightarrow 4H^+ + 4e^-$ (1)

$4e^- + O_2 + 2H_2O \rightarrow 4OH^-$ (1)

Overall equation $2H_2 + O_2 \rightarrow 2H_2O$

(ii) Unchanged   (1)
(d) Economic disadvantage; Use of CH_4 or cost of producing or high temp   (1)

Environmental disadvantage;   Makes CO_2 (1)

(e) Cost of manufacture of solar cells   (1)

Question 4

(a)	Species	$[Co(H_2O)_6]^{2+}$	(1)
	Precipitate	$Co(H_2O)_4(OH)_2$	(1)
(b)	$[Co(NH_3)_6]^{2+}$		(1)
(c)	Reaction	Oxidation	(1)
(d)	Reactant	Oxygen in the air	(1)
	R	Iodine	(1)
	Explanation	$[Co(H_2O)_6]^{3+}$ oxidises I^- to I_2	(1)

Question 5

(a) $Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$ (1)

(b) $MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$ (1)

(c)   Moles MnO_4^- in 19.6 cm^3
        $= 19.6 \times 0.022 \times 10^{-3} = 4.312 \times 10^{-4}$ (1)

        Moles Fe^{2+} in 25 cm^3
        $= 5 \times 4.312 \times 10^{-4} = 2.156 \times 10^{-3}$ (1)

        Moles Fe^{2+} in 250 cm^3
        $= 10 \times 2.156 \times 10^{-3} = 2.156 \times 10^{-2}$ (1)

        Mass $Fe^{2+} =$ moles $\times A_r$
        $A_r = 2.156 \times 10^{-2} \times 55.8 = 1.203g$ (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. $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$

Species   (1)
Balance   (1)

Colours:
e.g $[Cu(H_2O)_6]^{2+}$ blue   (1)
e.g. $[CuCl_4]^{2-}$ yellow/green   (1)

(b)   (i) ΔE :-   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 $1/2N_2 + 3/2H_2 \rightleftharpoons NH_3$ (1)

$\Delta Hf = [(945 \times 0.5) + (426 \times 1.5)] - (391 \times 3)$ (1)

$= -46.5$ kJ mol^{-1} (1)

Mark Range	The marking scheme for this part of the question includes an overall assessment for the Quality of Written Communication (QWC). There are no discrete marks for the assessment of QWC but the candidates' QWC in this answer will be one of the criteria used to assign a level and award the marks for this part of the question **Descriptor** an answer will be expected to meet most of the criteria in the level descriptor
4-5	- claims supported by an appropriate range of evidence - good use of information or ideas about chemistry, going beyond those given in the question - argument well structured with minimal repetition or irrelevant points - accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling
2-3	- claims partially supported by evidence - good use of information or ideas about chemistry given in the question but limited beyond this - the argument shows some attempt at structure - the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling
0-1	- valid points but not clearly linked to an argument structure

	- limited use of information or ideas about chemistry		
	- unstructured		
	- errors in spelling, punctuation and grammar or lack of fluency		

(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
and allow more ammonia to be produced in a given time   QWC   (1)
                                                             (1)

Question 8

(a) $FeCl_3$ accepts electron pairs from water   (1)

Hence acts as a Lewis acid   (1)

$[Fe(H_2O)_6]^{3+}$ donates protons   (1)

Hence acts as a Bronsted-Lowry acid   (1)

(b)   The Fe^{2+} ion has a smaller charge to size ratio   (1)

Hence less polarising than Fe^{3+} or less weakening effect on O-H bonds   (1)

(c)   (i)
     $V_2O_5 + SO_2 \rightleftharpoons V_2O_4 + SO_3$ (1)

     $V_2O_4 + O_2 \rightleftharpoons V_2O_5$ (1)

(ii)   Both ions are negative or ions repel   (1)

$2Fe^{2+} + S_2O_8^{2-} \rightleftharpoons 2Fe^{3+} + 2SO_4^{2-}$ Species   (1)
    Balanced   (1)

$2Fe^{3+} + 2I^- \rightleftharpoons 2Fe^{2+} + I_2$ 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