

**2854 Chemistry (Salters): Chemistry by Design**

**January 2004**

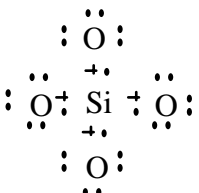
**Mark Scheme**

The following annotations may be used when marking:

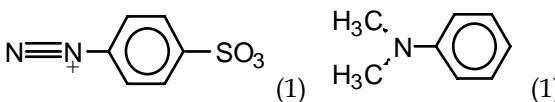
X	=	incorrect response (errors may also be underlined)
^	=	omission mark
bod	=	benefit of the doubt (where professional judgement has been used)
ecf	=	error carried forward (in consequential marking)
con	=	contradiction (in cases where candidates contradict themselves in the same response)
sf	=	error in the number of significant figures

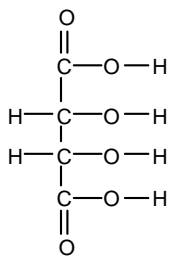
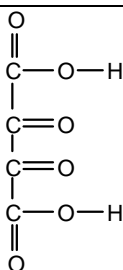
Abbreviations, annotations and conventions used in the Mark Scheme:

/	=	alternative and acceptable answers for the same marking point
;	=	separates marking points
NOT	=	answers not worthy of credit
( )	=	words which are not essential to gain credit
___ (underlining)	=	key words which <u>must</u> be used
ecf	=	allow error carried forward in consequential marking
AW	=	alternative wording
ora	=	or reverse argument

Question	Expected Answers	Marks
1 a	4 (1); In Group 4/ same group as carbon/ worked out from atomic no. (1);	2
1 b i	 <p>four pairs of electrons electrons round Si (1); these shown as dot-cross (1) eight electrons round O ("extra" electron could be shown by some other symbol) (1);</p>	3
1 b ii	four pairs of electrons/ areas of electron density <u>round Si</u> ( <i>stated or implied</i> ) (1); repel ( <i>award if in context of electrons</i> ) (1); get as far away from each other as possible/ minimise repulsion( <i>can be in context of bonds or atoms</i> ) (1);	3
1 c i	they/layers are negatively charged/ metal ions are positively charged	1
1 c ii	aluminium ( <i>allow Al</i> )	1
1 d i	fewer electron <u>shells</u>	1
1 d ii	correct answer: K <sup>+</sup> (1)  K <sup>+</sup> lowest charge density (in context of attracting water) / attracts fewest water molecules / lowest attraction for water / becomes less hydrated ( <i>ora for Li<sup>+</sup></i> ) (1)  K <sup>+</sup> (aq) has lowest effective radius / highest charge density / strongest attraction for clay / Li <sup>+</sup> (aq) has formed more bonds with water / water molecules obstruct / reduce attraction of Li <sup>+</sup> (aq) for clay (1)	3
1 e	SiO <sub>2</sub> Solid – CO <sub>2</sub> gas / in terms of melting or boiling points(1); SiO <sub>2</sub> insoluble – CO <sub>2</sub> (slightly) soluble(1)  <i>plus four from:</i> CO <sub>2</sub> <i>covalent bonds</i> (1); (small) <i>molecules</i> (1) <i>weak imf/ instantaneous dipole-induced dipole forces</i> between molecules easily broken (1); <i>hydrogen bonds</i> with water (1) SiO <sub>2</sub> ; <i>network/giant/lattice structure</i> (1); <i>covalent bonds</i> hard to break (1)  QWC <ul style="list-style-type: none"> <li>• <i>at least two sentences/bullet points,</i></li> <li>• <i>logical,</i></li> <li>• <i>at least three italicised terms used correctly in context</i></li> </ul> <i>All the above – (2) only 2 italicised word (1)</i>	6
		2

2 a i	(secondary) amine, alkene, ketone/carbonyl	3
2 a ii	16	1
2 a iii	Idea of groups <i>across</i> double bond (1);	1
2 a iv	lack of free rotation at double bond (1)	1
2 b i	d block/transition metal	1
2 b ii	Co <sup>2+</sup> + 2OH <sup>-</sup> → Co(OH) <sub>2</sub> 2+ on Co (1) rest correct (1) 2Al(OH) <sub>3</sub> → Al <sub>2</sub> O <sub>3</sub> + 3H <sub>2</sub> O Al <sub>2</sub> O <sub>3</sub> (1); Rest correct (1)	4
2 c i	Idea of quantity being made and then process started again (1);	1
2 c ii	Small amounts needed/ difficulties of getting precise quantities (1)	1
2 c iii	Release of HCl (1); Acidic gas/ Irritant (1)	2
2 d i	SiCl <sub>4</sub> , PCl <sub>3</sub> , PCl <sub>5</sub> , S <sub>2</sub> Cl <sub>2</sub> , SCl <sub>2</sub> element (1); formula (1)	2
2 d ii	M <sub>r</sub> AlCl <sub>3</sub> = 133.5 (1); Amount of AlCl <sub>3</sub> = (4.5/ 133.5 ( <i>ecf</i> ) (= 0.0337 mol)(1); M <sub>r</sub> CoCl <sub>2</sub> .6H <sub>2</sub> O = 238(1); Mass of CoCl <sub>2</sub> .6H <sub>2</sub> O = 0.0337 × 238( <i>ecf</i> ) = 8.0 g (1); 2 sig figs ( <i>mark separately</i> ) (1)	5
2 e i	indigo is more purple/yellow/green / indigo is lighter (1); it reflects more red/other frequencies <i>ora</i> / more components of white light reflected (1);	2
2 e ii	two energy levels (1); <u>electrons</u> excited / absorb energy to be promoted to higher energy level (not awarded if "drop back" included in the answer) (1);  <i>plus 2 from:</i>  <u>difference</u> corresponds to red/ non-blue colours; being absorbed from <u>visible light</u> ; blue light reflected (not emitted); <i>or one from:</i> <i>band absorption</i> in compound (1); caused by <i>vibrations</i> in each level (1); blue light higher energy than red (1); energy levels close because of complex structure of molecule (1) $E = h\nu$ (1)  <i>Any of these shown on a diagram should score</i>	4
2 f i	$  \begin{array}{c}  \text{H} \\    \\  \text{H}-\text{C}-\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R} \\    \\  \text{H}-\text{C}-\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R} \\    \\  \text{H}-\text{C}-\text{O}-\overset{\text{O}}{\parallel}{\text{C}}-\text{R} \\    \\  \text{H}  \end{array}  $ <i>not necessarily full structural</i> glycerol stem correct (1); completely correct	2
2 f ii	They have (carbon-carbon) double bonds	1
2 f iii	bromine water/solution/aqueous (1) decolorised (1)	2

3 a i	Red (1); Acid contains H <sup>+</sup> /fully ionised(1); pushes equilibrium to left (1)	3
3 a ii	SO <sub>3</sub> <sup>-</sup> /sulphonate	1
3 b i	incomplete reaction/ionisation /equilibrium (with water) (1);	1
3 b ii	pK <sub>a</sub> = -log K <sub>a</sub>	1
3 b iii	$K_a = \frac{[\text{H}^+][\text{yellow form}]}{[\text{red form}]}$ 2 marks if correct. one if wrong way up	2
3 b iv	If [yellow] = [red], K <sub>a</sub> = [H <sup>+</sup> ] (1); (pK <sub>a</sub> = pH) pH = 3.7 (1)	2
3 c i		2
3 c ii	sodium hydroxide <i>allow NaOH</i> / below 5°C (1)	1
3 d i	benzenesulphonic acid (1);	1
3 d ii	concentrated (1) sulphuric acid (1); (heat under) reflux (1)	3
3 d iii	electrophilic (1); substitution (1)	2

4 a i	$C_2H_3O_3$ (2) <i>Molecular formula <math>C_4 H_6 O_6</math> scores (1)</i>	2
4 a ii	 <p style="text-align: center;">carboxylic acid groups correct (1); fully correct (1)</p>	2
4 a iii	(1) for each central carbon atom ringed	2
4 a iv	$C_4H_6O_6 + 2NaOH \rightarrow C_4H_4O_6Na_2 + 2H_2O$ <i>or with structural formula ionic representations of salt.</i> Left-hand side correct (1); Idea of a salt formed (1); Completely correct (1)	3
4 a v	 <p style="text-align: center;"><i>not necessarily full structural</i> Reaction at central -OH groups (1); completely correct (1)</p>	2
4 b i	Amount = $12.0 \times 0.100/1000$ (1) = $1.20 \times 10^{-3}$ mol (1)	2
4 b ii	Amount of $H^+$ in $100 \text{ cm}^3$ wine = $4.80 \times 10^{-3}$ mol <i>i.e. factor of four</i> (1) Amount of tartaric acid = $2.4 \times 10^{-3}$ mol <i>i.e. divide by two</i> (1) Mass of tartaric acid = $2.4 \times 10^{-3} \times 150 = 0.36\text{g}$ <i>multiply by 150</i> (1)	3
4 c i	aldehyde	1
4 c ii	HCN	1
4 c iii	nucleophilic (1); addition (1)	2
4 c iv	$H^+(aq)/H_2O$ Reflux	1
4 d	Identified as ethanoic acid (name or structural formula) (1) <i>Plus six marks from the following, TWO from each spectrum</i>  <i>Mass spectrum</i> $M_r$ /relative molecular mass = 60; Fragment identified (eg loss of $CH_3$ at 45, loss of OH at 43);  <i>i.r. two from</i> O-H; C=O; C-O  <i>n.m.r two from:</i> two H environments ; ratio 3:1; Identify 2.0 peak as $CH_3CO$ .	7

5 a	Statement of Le Chatelier (AW) (1); Reaction trying to restore temperature (1)	2
5 b i	$[\text{Ca}^{2+}] \times [\text{CO}_3^{2-}]$ Idea of calcium and carbonate ions multiplied together(1); concentrations(1)	2
5 b ii	$[\text{Ca}^{2+}] \times [\text{CO}_3^{2-}] = 10^{-10}$ (1); this is smaller than $K_{sp}$ (1) thus no pptn (1)	3
5 c i	$\Delta S_{\text{sys}} = -53.1 - 56.9 - 92.9$ (1) = $-202.9 \text{ J mol}^{-1}\text{K}^{-1}$ (1) <i>ecf from any visible calculation</i>	2
5 c ii	$\Delta S_{\text{surr}}$ is positive (since reaction is exothermic) (1); becomes more positive at lower temps (1) $\Delta S_{\text{tot}}$ must be positive for reaction to occur (1)	3
5 d	<p>CO<sub>2</sub> causes greenhouse effect/global warming (1) <i>Two from effects</i> (1) (1) ice cap melting/ sea level rising; changes to weather patterns; changes to climate; changes to agriculture;</p> <p>Not being done because <i>two from</i> (1) (1) Technology not developed; Expensive; In equilibrium hence CO<sub>2</sub> would slowly re-appear; Could affect life in deep ocean</p> <p><i>QWC SPAG - At least 2 consecutive sentences, allow one spelling mistake.</i></p>	<p>5</p> <p>1</p>